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Washington, DC



Proceedings National Workshop

Integrated Ecological and Resource Inventories

Phoenix, Arizona
April 12-16, 1993



USDA Forest Service/NAL 399503

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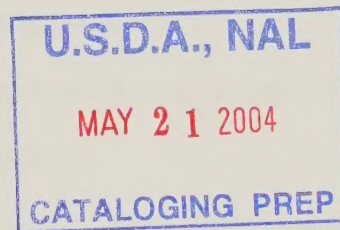
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Proceedings National Workshop

Integrated Ecological and Resource Inventories

WO-WSA-4

Phoenix, Arizona
April 12-16, 1993



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EXECUTIVE SUMMARY

About 170 attended including representatives from all Regions, Stations and the Northeastern Area. Included were representatives from the Soil Conservation Service (SCS), Environmental Protection Agency (EPA), Fish and Wildlife Service (F&WLS), Bureau Of Land Management (BLM), US Geological Survey (USGS) and The Nature Conservancy (TNC).

A wide variety of disciplines attended providing the diverse viewpoints needed to formulate good recommendations. New approaches on information management and incorporating the human dimension into ecosystem management were presented and discussed. Participation from attendees was active and very productive. The Poster Session and several associated meetings were excellent and helped meet objectives.

There was strong agreement on the need for nationally consistent ecological classification, mapping and inventory direction. This includes standard frameworks, methods, definitions and data and information management.

Following are key recommendations that came from the Workgroups and the summary meeting Friday morning, April 16.

Ecological Classification and Mapping

1. Each Region, with appropriate Station representation, should establish an Ecological Classification, Mapping and Inventory Team (Regional Ecomap Team), and identify a contact person to coordinate with the WO Ecomap Task Team. Teams should include representation from the physical, biological and human dimensions.
2. Finalize and adopt the National Hierarchical Framework of Ecological Units developed by Ecomap. It is recognized that as we work with our partners, learn more about the landscape and find better ways to organize information, revisions will be made.
3. Regions agreed to complete draft Ecosubregion Maps of their region by May 15. These will be compiled on a 1:3.5 million scale map for review and matching. Teams should provide names and descriptions for the map units.
4. Ecomap should develop a Glossary for Ecological classification, mapping and inventory terms and concepts.
5. The Aquatic Subgroup of Ecomap agreed to finish development of the aquatic classification system and to integrate appropriate hydrologic factors with the Ecological Unit Hierarchy.

Human Dimension

The Human Dimension Team will continue to develop the Human Dimension concept paper. They will work with Regions and Stations to share information and refine the concept for use by planners and managers.

Integrated Resource Inventory (IRI)

1. Ecomap should pursue the consolidation and revision of manuals and handbooks related to integrated resource inventories, ecological classification and mapping and incorporate the many suggestions that were made by workgroups. Standard sampling techniques and minimum requirements should be established and consistently applied.

2. A National Standard Business Model for Ecosystem Management should be developed within one year. Establish an IRI Focus Area Team with membership from all organizational levels.

Planning and Monitoring

1. Forests should develop and use ecological land units (as defined in the Hierarchical Framework) as basic capability units for planning and monitoring. Data and analyses should be structured to facilitate coordination and information sharing across administrative and jurisdictional boundaries. This work should be accomplished before forest plans are revised.

2. Ecomap should review the desirability and utility of a series of permanent monitoring plots across all NFS lands for trend analysis and to link with FIA and EMAP with a set of core data measured on all plots.

These recommendations will be used to develop an Action Plan to provide the consistency needed to effectively integrate and conduct resource inventories, data collection, monitoring and information management. Ecological classification, mapping and inventory sets the stage for implementing ecosystem management through forest plan revision and other activities.

WORKSHOP OBJECTIVES

Jerry A. SESCO
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INTRODUCTION

Welcome to Phoenix and the national workshop on Integrated Ecological and Resource Inventories. Many of us participated in the Salt Lake City workshop last April. We established a vision there of better integration, coordination, consistency, and standardization in our classification, mapping, and inventory programs. I embraced that vision along with Jim Overbay, Deputy Chief for National Forest Systems. We also identified six principles for implementing an ecological approach to multiple-use management. This week we will focus on making one of those principles, "Integrated Data and Tools," a reality for the Forest Service.

During the last few years the Forest Service, other agencies, interest groups and the public in general have recognized and accepted a new vision for public land management. It's based on a much broader view of interactions and linkages between humans and our environment. The focal point of this change is using a better blend of science and human values to determine the appropriate balance between the environment, economic considerations and the life styles of the communities we live in.

As a very recent example of our shifting emphasis, President Clinton made the following five points at the closing of the Forest Conference in Portland:

"We must never forget the human and the economic dimension of these problems"

"We need to protect the long-term health of our forests, our wildlife, and our waterways"

"Our efforts must be, insofar as we are wise enough to know it, scientifically sound, ecologically credible, and legally responsible"

"The plan should produce a predictable and sustainable level of timber sales and non-timber resources that will not degrade or destroy our forest environment"

"We will do our best to make the federal government work together and work for you"

Earlier, Secretary of Agriculture Espy had given a speech before the North American Wildlife and Natural Resources Conference. He presented a set of concepts designed to improve USDA's fulfilling its conservation mission and stewardship role. These concepts closely parallel the President's message, but a couple are worth highlighting:

"Sound policy must be based on sound science"

"We must ensure that we understand the spatial and temporal effects of our management decisions."

THE CHALLENGE

Why do we need consistency? What has brought us to this urgency?

The purpose of the Workshop is stated right at the top of the agenda. It reads, "to develop minimum standards and guidelines for ecological and resource mapping, ecological classification, inventories, and monitoring to ensure integration, consistency, linkage with the human dimension, and comparability across Forest Service Units."

This means that we as a public land management agency need to take a hard look at the way we have traditionally done business. We need to adapt quickly to this new view of natural resources we call ecosystem management. We seem to have a new and controversial issue every week. The courts, and the newspapers, are airing cases like spotted owls, grizzly bears, red cockaded woodpeckers, and anadromous fisheries. Everyone seems eager to help "prescribe" the attributes of dealing with a single species, but we need to answer in terms of a broader, landscape scale, response.

The Forest Service has adopted and embraced ecosystem management. Other agencies are moving in the same direction. With this has come the realization that ecosystems cross administrative and political boundaries. Comprehensive analysis of resource issues requires evaluation across multiple ownerships and at multi-forest scales. To carry out such evaluations requires a common language and sufficient standardization in ecological classification, mapping, and inventory programs to allow us to share and aggregate data and information.

Funding is scarce for ecological classification, mapping, and inventory. It requires us to aggressively seek ways to integrate our efforts and prevent duplication. The Agency recognizes that this work is expensive and time consuming, but an essential building block for ecosystem management. Internal and external sharing is crucial to efficiently combining data and information for ecosystems.

Communicating with our publics and other agencies is very important as we aggregate data for reporting, conduct joint analysis projects, compare plans and efficiently conduct our business in general. This need for effective communications requires common terms and definitions.

I can't over emphasize the need for the Forest Service to be able to communicate clear, coherent, and consistent information to Congress, the Administration, and the public. If we can't do this, other sources of information - not always accurate - compete with our data as the basis for public debate and action. The issue of the definition and amount of old growth in the Pacific Northwest is a good example of this concern.

So, where does that put us? The Forest Service has been classifying land, conducting resource inventories, and mapping these resources for well over 30 years. Based on that, you might think we have our act together: that we know how to consistently and efficiently do these jobs so that data and information

is effectively used and shared between units, staffs, and other agencies. Well, I think you know the answer. We aren't there yet! We have embarked on the Journey. But now we are at the point where we urgently need to establish consistency in our mapping and inventory programs. We need to establish a solid, scientific foundation for our leadership role in ecosystem management. That's why we are here this week.

OUR PROGRESS

What progress have we made towards achieving consistency and integration?

I want to recognize the excellent work being done, and not give the impression that we have to start from ground zero. You only have to review the Salt Lake City proceedings to see that substantial accomplishments are being made. We are also impressed with the Region and Station efforts during the last year. Nearly every Region has an Inventory and Mapping team set up to coordinate regional programs and interface with EcoMap. All the Region/Station ecosystem management strategies include ecological classification, mapping, and inventories as important components.

There are some long standing successful programs and several Regions have embarked on innovative inventory and mapping programs in the last couple of years. The recent work in some Regions and Stations on information needs assessments, common data dictionaries, developing linkages between resource data bases and recognition of the human dimension, demonstrates we are moving in the right direction towards a common structure for handling data and information. We have much to build on!

There are excellent examples in both the Regions and Stations where close and substantial coordination with other State and Federal agencies and private groups has enhanced data collection and sharing as well as improve our analysis and decision making process. This type of coordination needs to be increased right up front in our mapping and inventory processes.

We want you to know that we recognize what you have accomplished. And that we want to build on those successes.

SALT LAKE CITY WORKSHOP RESULTS

Before we take a look at what needs to be done, let's back up to the Salt Lake City Workshop and briefly review what we decided there.

At our National Workshop last year on **"Taking an Ecological Approach to Management"** one of the principles of Ecosystem Management from the White Paper and Overbay's speech states: "Planning and management needs integrated data and information on all ecosystem components."

The Conference participants were told to "develop, complete, refine, and use integrated ecological classifications, multi-resource inventories, geographic information systems, and prudent monitoring systems to integrate what we need to know about geology, landform, soils, climate, conditions of plant and animal communities, biodiversity, and peoples preferences to improve our management of public resources."

And it was suggested we do this with national standards for consistency across administrative boundaries.

The Conference participants responded by formulating three general statements relating to ecosystem classification, mapping, and inventory. It was decided that we:

1. Standardize ecosystem classification and mapping definitions, methodology and terminology, and establish a hierarchical structure of ecological units.
2. Define the minimum national level inventory and map information required for ecosystem management and develop minimum standards and guidelines to ensure that these data are accurate, consistent, and comparable.
3. Develop a strategy for timely completion of a coordinated mapping and inventory program to support ecosystem management.

OUR DIRECTION FOR THIS WEEK

As you know, we have collectively made some progress on these actions, but much more needs to be done. Based on the Salt Lake City recommendations and your responses to our questionnaire, we have identified three general areas needing your attention this week.

FIRST, we want to develop an Integrated Information Structure

Let me take a moment here to share some comments on our effort from Bill Bristow, the agency's new Chief Information Officer. Bill understands it as his responsibility to make sure that standards necessary for integrating information are developed and promulgated throughout the agency. He intends this to be accomplished under the umbrella of the Information Management Framework developed last year by the Chief's Information Management Task Force under the leadership of Hank Montrey. He sees, for instance, standards regarding minimum inventory layers for GIS as something needed ASAP and has designated the 6600 series of the Forest Service Handbook as the conduit for establishing these standards agency-wide. Some of Bill's people are here this week to join in our efforts to make integrated inventories a reality. We welcome them and appreciate their help in moving this matter forward aggressively. For this workshop, we specifically want to:

- * Develop a National Standard Business Model for Ecosystem Management. We have some examples to share with you. This is needed to guide development of a corporate integrated inventory data base to be used with GIS.
- * Develop standard data dictionaries so we are all naming, measuring, and recording the same things.
- * Put together a National Glossary on Ecosystem Management so we can communicate more efficiently.

SECOND, we want to establish a framework for Strategic Planning, Organization and Budget for ecological classification, mapping, and inventory. The plans should facilitate integration, line commitment, and set clear objectives.

THIRD, we want to define Uniform Processes for Ecological Classification and Resource Mapping and Inventory. We want to structure all of our classification, mapping, and inventory programs so that they are organizationally linked and standardized. Direction must be consistent with GIS and encourage the use of Remote Sensing and other related technology. We have been moving towards integration and use of new technology for a long time, but progress is spotty.

Now we need to make it happen! In your work groups, it will be your job to:

- * Develop Handbook direction for major gaps that currently exist for ecological classification, mapping, and inventory. We must ensure that the physical, biological, and human elements are integrated. The human dimension needs to be a full partner in ecosystem management.

- * Clearly provide direction on how ecological units are used in LMP and in analysis at broad geographic scales. I think it may be time to decide to have all inventory data registered to basic Land Units to develop a permanent spatially related data base.

These are the major items outlined for work group assignments. It's a tall task but I'm sure you are up to it.

CONCLUSION

This Workshop is the key to more effectively organize ourselves and make personal commitments and decisions on a course of action that will move us closer to our goal of consistency and integration.

The work you do here this week is very important to the Forest Service. Professionally sound data, maps, and inventories are the foundation for effective implementation of ecosystem management. Our need for quality and consistent information is urgent. I'm asking you to spend this week in a true interdisciplinary manner.

The output from your work groups should be in the form of draft direction and not suggestions for future actions or task groups unless absolutely necessary. If you recommend an Action Plan, be specific with charges, timelines, and suggested team members. You are the experts in the field--you have the knowledge and we are giving you the time. We need your decisions for national direction.

Have a rewarding week. We look forward to your products!

ECOLOGICAL CLASSIFICATION, MAPPING, AND INTEGRATED INVENTORY TASK TEAM
ECOMAP

Peter E. Avers, CHAIRPERSON

Purpose

This Task Team is organized to improve the coordination, integration, and standardization of ecological classification and resource inventories. The basis for this work is primarily the recommendations and ideas generated by the Inventory Work Group at the Salt Lake City Ecological Approach To Management Workshop. In addition, the principles and guidelines for ecosystem management sent out by the Chief in the June 4 and June 25, 1992 letters add further emphasis.

The SLC Conference decided that the Forest Service should develop a hierarchy of ecological units, develop minimum standards for resource inventories to gain National consistency, and to develop a strategy for timely completion of a coordinated mapping and inventory program to support ecosystem management.

The goal of Ecomap is to implement the SLC decisions and to increase the efficiency and effectiveness of making and using inventories. Results will improve the quality of agency decisions and promote a better understanding of the relationships of ecosystems, including humans, to land and resource planning and management.

Scope

The Task Team will develop frameworks and direction for ecological classification, mapping and integrated resource inventory systems and provide mechanisms to ensure the direction is implemented and monitored in the field. Team efforts will build upon existing direction and take full advantage of current work being developed in the field. Liaison will be maintained with other proposed Task Teams such as those on infrastructure, social, economic, and political systems. Communication, cooperation, and liaison with potential partners concerned with resource inventories and ecosystem management is planned.

The scope includes the following mapping and inventory efforts:

Terrestrial ecological units (soils, geology, climate, landform, potential natural vegetation and topographic features - FSH 2090.11). Terrestrial inventories include riparian areas and wetlands.

Aquatic ecological units (classification and inventory of streams, lakes and other water bodies).

Existing vegetation.

Population and distribution data on selected species (plants and animals).

Other resource inventories such as social, economic, cultural, etc.

Triple Dimension of Ecosystem Classification and Mapping

Ecosystem classification, like ecosystem management, requires the recognition and integration of the Stable (mostly physical), Transient (mostly biological) and Human dimensions. To achieve this requires an overlay system that allows spatial comparison and evaluation of appropriate data from each dimension. The Stable dimension includes the relatively unchanging part of the environment such as climate, landform, geology, soils and the occurrence of lakes, rivers and streams. These form the basis for ecological unit inventories and include both water and terrestrial units. The Transient dimension includes classification and inventories of biological and physical components that are affected by disturbance regimes, ecological processes and basic land capability. Primary examples are fish and wildlife populations, water quality and existing vegetation. The human dimension adds a wide array of social and economic elements related to values, markets, infrastructure, cultural resources and political realities that affect planning and management of ecosystems.

Ecological Classification and Mapping

What do we mean by ecological classification and mapping? Ecological classification relates to the stable and transient dimensions, for the most part. Some cultural and historical aspects are also factored into the classification. Humans, of course, construct the classifications and stratify the land to meet social needs. All three dimensions are used, but at varying degrees, depending on scale and the purpose of the work. The proposed FSM 1920 defines it as an integrated hierarchical framework for classifying ecological types and stratifying land into ecological units that have unique combinations of potential natural vegetation (PNV), soil, geology, landscape features, climate, animal populations, stream channel, hydrologic and aquatic characteristics. The human dimension needs more visibility in this definition.

Under current use, ecological classification refers to a land classification system that defines a taxonomic classification of ecological types and provides a basis for designing and mapping ecological units. FSH 2090.11 defines Ecological Types as "A category of land having a unique combination of PNV, soil, landscape features, climate, and differing from other types in its ability to produce vegetation and respond to management." An Ecological Unit is defined as "A mapped landscape unit designed to meet management objectives, comprised of one or more ecological types." Ecological units are geographic land areas that are characterized primarily by the physical components of the landscape affecting ecological potentials. The use of biotic factors, such as potential natural vegetation, in the classification of ecological types and the mapping of ecological units, helps to identify classes and areas of biophysical, or ecological, significance. These ecological units include both terrestrial and aquatic.

The process of ecological classification draws on taxonomies of vegetation, soil, geology, water, landforms and climate to design a classification of ecological types and map units. These individual classifications are needed to understand component systems due to the complexity of ecosystems. They are also needed for component inventory and data bases, and as a means to characterize and describe map units. It is the integration of individual systems into a unifying taxonomic and spatial framework, however, that makes an

ecological classification and mapping system "ecological". Thus, the process includes the integration of separate themes of information through interdisciplinary team efforts. The final classification and map units are derived through front end integration, where components are mutually defined; or by integrating independently developed taxonomies and maps while rectifying conceptual and spatial discrepancies to arrive at integrated units.

As stated, ecological classification strives to classify land and water units from an integrated abiotic and biotic perspective. The interrelationships and influences of the components help to understand the structural and functional potentials of the map unit. The idea is to pull component resource data together to define structurally integrated units of land and water as they occur on the earth's surface at various geographic scales.

The map units are functioning integrated systems with definable resource potentials and predictable responses to treatment and disturbance. Our job, based on the stated purpose of the map, is to understand these systems sufficiently to establish classes and determine meaningful map boundaries.

Ecological Unit Inventories

Ecological Unit Inventories (EUI) are defined in the proposed FSM 1920 as Inventories that are based on the stable and transient components of the landscape and provide information about the production capabilities, biodiversity potentials, management opportunities and limitations to land use. EUI's are developed by an interdisciplinary team and form the basis for land capability determinations and potentials for land management planning, monitoring and evaluation.

Ecological map units are designed by (1) using ecological types with common attributes or (2) stratifying land by using classes of landscape components associated with ecological types. Both are methods of ecological classification and are used to produce maps of ecological units. The first is common at the Land Unit level, or lower part of the Hierarchy of Ecological Units; and the second at upper levels for delineating Ecoregions or Ecosubregions. When done together it is considered a "bottom up and top down" approach to ecological classification. The result is a set of maps of ecological units at various geographic scales in a nested spatial hierarchy.

The technology of mapping is part science and part art. The intended use and objectives for making a map, and the quantitative methods (science) used to establish map unit criteria, provide the basis for boundary placement. Even so, considerable judgement is needed to draw (art) boundaries that reasonably represent the designed map units. The challenge comes from the fact that ecosystems and the landscape components used in map unit design often change as gradients and are continuums on the earth's surface. Ecosystems and ecological units rarely have distinct boundaries for the artificial classes we establish to meet perceived needs or objectives.

There are distinctly different ecological types but boundaries between them can be gradual or diffuse in many landscapes. The indistinct boundaries are a challenge to map makers. Users must recognize the purpose and limitations of maps. Ecological unit maps represent the pattern and distribution of the different types as designed by the interdisciplinary team and defined in the

map unit descriptions. Maps are useful to help us spatially and structurally understand our land base, organize our data, provide inventories of landscape components and show land and water areas with capability and suitability differences important to planning, analysis and decision making.

Integrated Resource Inventories (IRI)

The term Integrated Resource Inventories includes most mapping and inventory efforts that may be accomplished in an integrated manner. Generally, most of our inventories collect extensive data on one landscape component and limited data on other components. Even so, they can be considered an integrated inventory according to current definitions. Examples of predominately single component inventories, that often integrate other components, are existing vegetation, cultural resources, aquatic, potential natural vegetation, wildlife, fish, soil and geology. IRI's may include inventories of two or more transient components or an ecological unit inventory along with one or more transient components. National direction in FSH 1909.14 describes some of the integration, coordination and consistency requirements. However, this may need updating to gain the close integration and coordination desirable for achieving the current consistency goal.

IRI are used for a variety of mapping and inventory programs and efforts. It is often used generically. However several regions and stations have very specific, but quite different uses. As a consequence, IRI has become confusing for many and needs better definition for consistent application.

Guidelines

The Task Team will function within the following general guidelines as specific objectives are implemented:

Develop inventory policies that lead to the delineation of functioning ecosystems and the effective integration of resource uses based on concepts of sustainable ecosystem management including social and economic relationships.

Design inventories that support land capability evaluations, provide needed information for LMP and RPA, contribute to effective monitoring and evaluation and provide an ecological approach to multiple use management.

Coordinate data collection and inventory design with the information management framework, particularly GIS development and implementation.

Develop policies such that inventory systems and associated reporting systems allow for describing ecosystems at multiple geographic and time scales. Define the levels of information needs and identify the scale (temporal and spatial) and intensity of sampling and data collection.

Ensure that inventories are designed to promote understanding of ecosystems including ecological relationships between and within ecosystems, dynamic processes that shape and sustain ecosystems, variability in natural and managed ecosystems and human uses, values and relationships.

Build upon direction already established and successful region/forest programs.

Coordinate objectives with other agencies, groups and the Federal Geographic Data Committee (FGDC) to foster compatibility and sharing of data.

Specific Objectives

1. Standardize ecological classification, mapping and resource inventory definitions and approaches to meet National information needs for terrestrial and aquatic components of the ecosystem. This includes examining the feasibility of using one integrated inventory system for all National Forests and Grasslands. Update FSH 1909.14 and FSH 2090.11 as appropriate. (Begin FY92 - Complete FY93).
2. Develop minimum standards and guidelines (methods and processes) to ensure that inventory data and maps are accurate, integrated, consistent and comparable. (Begin FY92 - Complete FY94).
3. Develop and adopt a hierarchical structure of ecological units to address various geographic scales of ecosystem analysis. (Begin FY92 - Complete FY93).
4. Develop a strategy for timely completion of a coordinated mapping and inventory program to support ecosystem management. Recommend multi-functional funding as appropriate. (Begin FY93 - Complete FY93).
5. Develop a strategy for incorporating or displaying human and community relationships to resources to ensure compatibility with ecological classification and inventory operations, analysis and display. (Begin FY93 - Complete FY94).

Task Team Members

Peter Avers, WS&A
Doug MacCleery, TM
Tom King, M&G
Wini Kessler, RGE
Gordon Stuart, CF
Greg Super, REC
Chris Topik, WL&F
Gyde Lund, FIERR
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Rob Mrowka, TM
Bob Bailey, LMP
Janette Kaiser, RGE
Rich Calnan, IF
Jim Fenwood, WL&F

Task Team Function

Primary work to achieve objectives will be carried out by Subgroups made up of appropriate Task Team members, field specialists and managers. The Task Team will provide the necessary oversight, coordination and review of Subgroups.

Task Team members will serve on Subgroups depending on skills, interest and time available. The Task Team will discuss how to best achieve objectives.

The Task Team will be Chaired by Peter Avers and activities will be coordinated through the Deputy Director for Ecosystem Management. For simplicity, the short name for the Ecological Classification, Mapping and Integrated Inventory Task Team will be EcoMap.

Status of Ecomap Activities

Membership on Ecomap includes WO representatives from all Deputy areas. About 40 other "members" from the regions and stations are active on Subgroups. Most regions have formed Regional mapping and inventory teams. Some include researchers. Teams include soil scientists, foresters, geologists, hydrologists, ecologists, information specialists, biologists, etc.

Hierarchy of Ecological Units

1. Team prepared a white paper establishing initial framework of the hierarchy. Primary direction for the work came from existing National direction in FSM 2060 and FSH 2090.11. After internal and some external (TNC, BLM, SCS, F&WLS, EPA) review we have general consensus from all regions and at least two stations (SE & NC) on the framework. Hierarchy is four levels: Ecoregions, Ecosubregions, Landscapes and Land Units.
2. We have had two major work sessions, Eastern U.S. and Western U.S., to develop map unit design criteria and establish process and goals for Ecosubregion map completion.
3. Developed a new draft of the Ecoregion Map (primarily by Bob Bailey). It has been digitized by GSC.
4. All regions are currently completing early drafts of Ecosubregion Maps and some forests are completing Landscape level maps for use in LMP.
5. Coordinating work with F&WLS, TNC, SCS, USGS, NPS and others.
6. An aquatic classification system is being developed by fish biologists and hydrologists. Geologists are updating Physiographic Map for integration.

Plans

- a. Finalize the white paper on the National Framework after the Phoenix Workshop. Include in FSH 2090.11.
- b. Begin more active coordination with other agencies.
- c. Coordinate the completion of the regional Ecosubregion Maps. This includes matching at regional boundaries and correlation of map unit composition, names and written descriptions.
- d. Arrange for digitizing and decide who will be the "keeper" of the maps.
- e. Develop posters and illustrations to demonstrate hierarchy concept and use in the planning process.
- f. Participate in joint NFS-Research pilot monitoring project using EU's.

Information Management Subgroup - with the maps and inventories comes a need for a coordinated and integrated ecological data base framework. Several regions have done INA's and some have developed data base systems that are workable. The Region 1 Ecodata/Ecopac system may form the basis for a National system. There is considerable interest in the regions to have a common system. We have draft data dictionaries for soils and vegetation as a step in that direction. Geologic, air, topographic, etc., data dictionaries are envisioned.

The GIS standard data elements developed in 1990 serve as starting points. Plans:

1. Pursue a standard ecological data base system as part of the Agency-Wide Strategy Study to ensure compatibility with 615.
2. Several regions will be testing Ecodata this season.
3. Work on finalizing data dictionaries for soils, vegetation, geology, air, etc.

Below is a series of steps one may take to develop a corporate data base for the Forest Service. The first step is to use the FS methodology and business modeling to define our corporate needs at the National, regional, and local levels. The second is to develop strategic plans and get organized and budgeted. The third is to establish standard definitions, terms and encoding. The fourth step is to define common processes for classification, data collection, data stewardship (quality control) and analyses. The last step would be interpretation, reporting and presentation. This is followed by reviews to see that the plans are being implemented and appeals process to change any aspect of the corporate data base and data collection direction.

Steps for creating a corporate data base for ecosystem management including physical, biological, and human dimensions:

1. National Information Needs Analysis, Agency-Wide Strategy Study, Focus Area Strategy Studies, National Standard Business Models, ref. "Information Management: A Framework For The Future", FSM 1390, FSH 1909.14 Chap. 20.
2. Strategic Planning, Organizing and Budget Development ref. FSM 1912.3, FSM 1920.3, FSH 1909.14 Chap. 11.1, and FSH 2090.11.
3. Common Standards, Definitions, Terms. Ref. Interim Resource Inventory Glossary; Standards For Data And Data Structures ref. FSH 6609.15, and FSH 2409.14 Chap. 70.
4. Common processes (classification, data collection, analyses, and presentation) ref. FSM 2060, FSH 2090.11, FSH 1909.14 Chap. 10 and George Leonard's memo of October 16, 1992, etc.
5. Interpretation, Reporting, and Presentation ref. FSM 1912.3, FSM 1920.3, and FSH 1909.14 Chap. 11.1.

Note: Included in the steps above are some of the existing direction. Since the development of much of that direction, the agency has adopted Ecosystem Management.

Strategy Subgroup - This group has an important task but not much has been done yet. The goal is to improve coordination between NFS and Research in regards to all mapping and inventory work to prevent duplication, gain consistency and develop a strategy for timely completion of inventories. Efforts to kick off this task will be the issue paper and work group at the Phoenix Workshop.

Human Dimensions Subgroup - This subgroup has been working within Ecomap but the task is much broader than ecological classification and mapping. The group is very active and is planning to split off as a separate Task Team. They will continue to work on identifying relationships to ecological mapping criteria.

Summary

For the remainder of FY93 Ecomap will finalize the proposed National Hierarchical Framework of Ecological Units, publish the Ecoregion Map, complete the development of the Ecosubregion Map of the U.S., develop a draft glossary of ecological classification, mapping and inventory terms, develop a draft aquatic classification system, update the Human Dimension concept paper, increase interagency coordination, and begin to update National Manual and Handbook direction.

LAND MANAGEMENT PLANNING AND INFORMATION NEEDS

Joan Comanor, Director, Land Management Planning
(Delivered by Robert Bailey, Program Manager, Land Management Planning Systems)

Joan wants to thank you for inviting her to speak and expresses her regrets at being unable to attend the meeting. She acknowledges how important this week's effort is to her and to land management planning. Joan would like to challenge the participants in this workshop to think creatively about the important topics being discussed this week and offers the following food for thought.

Time is of the Essence.

It is important that a coordinated agency approach be reached now. We cannot afford to wait because:

The "next generation" of Forest Plans are coming onto line quickly with approximately 75 Forests moving into revision or major amendments during the next 3 to 5 years. Consistent with the Chief's policy statement of June 4, 1992, they are expected to incorporate an ecosystem management approach. Forest Plans and their implementation will manifest what we are going to do to implement ecosystem management. A core element to implementing ecosystem management through planning is an integrated inventory. Expectations of what Forest planning will do are even higher than in the first round of planning. Our own agency commitments to ecosystem management have raised these expectations both internally and externally. At the same time as expectations have increased, our management challenges seem more complex than ever.

Also, we are facing continued pressures to do more with less; to incorporate ecosystem management into Forest planning with tight budgets and fewer people. In that regard, we are trying to make the planning process more efficient and improve our approach based on the last decade of learning through experience.

With the cooperation of many staffs in the Washington Office and in the field, we have been working toward streamlining the Forest Planning process and will be proposing changes in the planning regulations and manual. Recently, we have spearheaded an effort to develop a prototype Forest Plan and EIS. Through these efforts we have learned that making the Forest Planning process more effective and efficient, and incorporating ecosystem management into this process, will require:

1. Adaptability. We have a general definition of ecosystem management but know that, as ecosystem management is put into practice, the specifics of how to implement this approach will evolve quickly. In your deliberations this week, you will need to build adaptability into your thinking on integrated inventories as well.

We have had difficulty adapting current Forest Plans to changing conditions. The process is in place for amending or revising Forest Plans but it is difficult and expensive to change them quickly enough

to respond to changing conditions. What makes it especially difficult is that many of the changing conditions are at a larger scale than covered by the administrative boundaries of Forests, for example, the problems with Forest health, habitat needs of threatened, endangered or sensitive species such as spotted owls and anadromous fish, goshawk, etc.

Changing conditions indicate the importance of temporal as well as spatial dimensions of ecosystem management. Ecological classification and mapping often emphasize the spatial dimension but the temporal is equally important. Many elements of ecosystems change over time, especially social and economic conditions; these normally change over a shorter time frame than biological or physical elements. We need to be able to respond as quickly to these changes as to the biophysical ones.

We also need to be able to identify and deal with gaps in our knowledge base. We must acknowledge that it is impossible to have all the current information about ecosystems. But we must plan based on what we have and use this information to determine what else we need. It is imperative to know what the risks are, based on what is known, and the risks we will be taking because of what we don't know--our knowledge gaps. Then we need to use monitoring and evaluation to validate what we do know and fill in the gaps in what we don't know; to keep building our knowledge base after decisions have been made rather than to wait to make a decision until we know everything.

2. Utility for decision making. One of the most important things learned from the first round of Forest Plans is the need to gather and analyze only the information needed for decision making. Not all the information collected and analyzed in the first round of planning was needed or useful for the decisions that were made. This time, we must be more efficient; we must gather only what will be used in making the Forest Plan decisions.

We must also recognize that integrating ecosystem management into Forest planning means that we may need different or additional information. Data will need to be collected so that information on the relationships among ecosystem components and resources, at multiple scales, and across administrative boundaries and over time can be developed, analyzed, and used in decision making. As more issues needing resolution arise that cross administrative boundaries, more consistency and comparability among Forests and even Regions will be required. Which brings us to the third element--

3. Efficiency through consistency. Reaching consistent terminology, definitions, inventory elements, etc., and applying these across all units will allow us to compare information across units and avoid the time and energy it requires to develop the crosswalks and other adjustments we so frequently have to engage in now.

Consistency does not mean having a cookie cutter and applying it to all situations. It does mean having some agreement on how we see the world. A starting point is an integrated inventory on each Forest so

that shared issues can be dealt with comparably and at least based on shared assumptions. And we need this consistency right away. Even now, it is too late for some of the Forests that are far along in revising Forest Plans. The longer we wait, the more Forest Plans will be developed without consistency or comparability in addressing shared issues. Again, public and internal expectations are not going to stack up favorably against that.

So, where do we go from here?

An interim strategy is essential; we need to stop looking for ultimate solutions because this search will overwhelm us. Little progress will be made toward solving our problems. An immediate strategy is needed to help Forests that are now beginning to develop inventories for revisions, and for those that will be starting to revise Forest Plans during the next 3-5 years. A longer term strategy is also needed for investments in systems, equipment and skills to improve management in the long term. The need for both near term and long term strategies must be understood internally and externally.

Knowing that data gaps exist, especially in data concerning relationships at given points in time and through time among resources or aspects of ecosystems, and that our time and money are scarce, we can't continue to depend on only our own data gathering. We need to fill in the gaps with the best available knowledge from wherever we can obtain it. We need to look at the techniques and sources of data that we are not currently making maximum use of.

We need to look at the institutional barriers to accomplishing these strategies, the organizational culture implications. Why have we not already developed coordination across our own administrative boundaries to develop consistency? Are we going to do better now? How? Why have we not coordinated more efficiently across government boundaries, with other federal, state, and local governments and Indian tribes? Are we waiting until we coordinate better among ourselves before we attempt intergovernmental or interagency coordination? We can't wait any longer, and we can't continue to insist that our solutions are the only right solutions as we try to work with others. We are receiving the clear message that we are one federal government and that lack of internal coordination is not acceptable. Part of the solution involves changing those elements of our organizational culture and the way we work with other agencies and governments that are barriers to our success in meeting today's challenges.

We have some glimpses of what our options might be. The coordination among government agencies in the Greater Yellowstone Area is one example. The MOU in California on biodiversity is another. This workshop offers the opportunity to investigate other possibilities for furthering coordination and cooperation.

These are the challenges; Land Management Planning can pose some of the appropriate questions but all of you must help provide the answers. This meeting provides an opportunity to move toward providing the solutions. This is critical to the success of the Forest Service and to making our planning and management efforts be all that they must be.

Following are some key questions to keep in mind while deliberating this week:

What can we do now for the 75 Forest Plans that will be undergoing revision or significant amendment in the next 3-5 years?

Is it possible to formulate a strategy into near term and longer term actions? What should the actions be for each phase?

What commitments and understanding must be in place to proceed with these actions?

Shall we proceed with the near term and longer term actions simultaneously or would it make more sense to proceed sequentially, at least for certain ones?

In conclusion, we very much appreciate the opportunity to participate in this workshop. Your efforts are important and we look forward to the outcome, particularly your ideas in response to the questions Joan has posed.

APPLYING HIERARCHICAL ECOLOGICAL CLASSIFICATION TO BIODIVERSITY AND NATURAL RESOURCE ASSESSMENTS

John R. Probst
U.S. Forest Service

Multi-resource management that maintains the full range of biodiversity considerations requires broad geographic assessment and planning. Local perspectives for comprehensive resource planning leads to conflicting prescriptions and monotonous landscape patterns. Local management focus on single-species approaches are too time-consuming and expensive to be practical or comprehensive enough. An alternative approach has been the use of ecosystems or communities as coarse filters for the species associations. Ecological classification can provide a general framework for assessing ecosystem diversity, species diversity and genetic diversity. However, using ECS surrogates for genetic and species diversity does not accommodate functional aspects of ecological relationships such as species interactions, dispersal, dynamic range borders, responses to disturbance, and numerous biogeographic relationships. To accommodate the need for finer resolution considerations down to species concerns it is necessary to construct gradients that aggregate or disaggregate the Ecological Units according to the problems and issues at hand.

Therefore, EC&I work could be integrated with issues by taking a comprehensive, hierarchical view of regional climate, landforms, ownership patterns, ecosystem interrelationships and multi-scale examinations of ecological processes such as nutrient dynamics or population interactions. Maps of Ecological Units and species ranges can be integrated at broader scales to help define common opportunities for regional biota. Species or issues also can be classified by general landscape pattern preferences such as area sensitivity, or affinity for interspersions. At finer resolution, species can be sorted not only by smaller-scale ECS Units, but by a variety of gradients for forest types or ages, habitats, habitat components, and special features. Many of these gradients cross EU categories or aggregate EU's.

Thus, the key to using Ecological Classification in a practical, intelligent manner is to focus on broader objectives first, and then choose combinations of Ecological Units as appropriate. This approach emphasizes parallel hierarchical thinking about ecosystems and biota rather than any one-to-one correspondence between EU scales and coarse to fine resolution assessments. A combined holistic-reductionist approach makes it possible to consider biodiversity comprehensively, without sacrificing detail needed for critical resources. However, valuable context can be provided by temporarily de-emphasizing single-issue management until coarse resolution work is initiated.

THE HUMAN DIMENSIONS OF NATIONAL FOREST ECOSYSTEM MANAGEMENT
An Issue Paper

Prepared By

The Human Dimensions Task Group

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Summary

"People are part of ecosystems and human conditions are shaped by, and in turn, shape ecosystems. People value and desire a broad spectrum of benefits (including survival) from ecosystems. In order to make effective ecosystem management decisions the Forest Service must have a scientifically sound and integrated understanding of the physical, biological and human dimensions of ecosystems. The human dimension of ecosystem management must include information about people's traditional and changing perceptions, beliefs, attitudes, behaviors, needs, and values and the past, present, and possible future influences of humans on ecosystems." --A proposed Ecosystem Management principle (3/31/93)

Ignoring or failing to fully consider the human dimension in ecosystem management is to slip backward to a time when the equation: "detailed physical evaluation plus sound technical judgement" appeared to yield the best natural resource management decisions. The recent past illustrates clearly the consequences of failing to fully understand the dynamics of the physical, biological and human dimensions of ecosystem management-- political controversy and hostile public reaction (including costly litigation) to what appears to be scientifically sound management. The Forest Service must blend the dynamic nature of human concerns and motivations with the biological and physical fabric of ecosystem management in order to have a credible and professional decisionmaking process.

Painful confrontations, appeals and litigation have made it clear that the public expects the Forest Service to consider the human dimensions of ecosystem management, not as an additive to the old model of management, but as an integral part of every aspect of natural resource management.

As a world leader in natural resource management, the Forest Service must lead the way in managing sustainable ecosystems to meet current and future human needs. This is difficult for several reasons. Most obvious is the requirement for a more fully integrated and adaptive management process. And, most challenging is successfully meshing the extended timeframe of nature with the compressed timeframe of humans. Processes and tools are needed to facilitate the development of an improved understanding of the ecosystem-related human perspective and experience, and to integrate that knowledge with the more familiar physical and biological dimensions.

Recognition of the human dimensions (including such areas as the spiritual, ethical, cultural, historic, aesthetic, economic and social concerns that people have) and how they affect and are affected by ecosystems, exists to varying degrees within the Forest Service. The Agency also currently lacks

appropriate tools and necessary scientific processes to consistently and effectively inventory and record social information. The Agency is closer to recognizing that its ecosystem management objectives cannot be fulfilled unless the human dimension is made a full partner in all ecosystem management decisions.

The issue paper reviews the subject in more depth and includes recommendations on incorporating the human dimension into Forest Service ecosystem management. This paper was developed by a team consisting of forest planners, landscape architects, social scientists, economists, and public affairs, recreation and ecosystem management specialists.

I. INTRODUCTION

The Forest Service has been doing ecosystem management for many years, although it has not always been not labeled as such. The Agency's organizational structure, infrastructure and output mix reflect its best interpretation of those values held by the American public. As those values have continued to evolve, sometimes in dramatic ways over the last few years, the Agency is changing how it responds to meet public wants and needs.

The Chief's June 4, 1992 letter outlines the Agency's approach to ecosystem management: "An ecological approach will be used to achieve the multiple-use management of the National Forests and Grasslands. It means we must blend the needs of people and environmental values in such a way that the National Forests and Grasslands represent diverse, healthy, productive and sustainable ecosystems."

The Chief's letter also states that the Agency is evolving by shifting the balance of its products and services in response to changing public demand--including a strong interest in leaving ecosystems intact and capable of being sustained over the long run. The new balance implies the Agency is moving from a commodity orientation to one where other values receive more attention, e.g., sustainable ecosystems, recreation, wildlife species preservation, aesthetics, cultural and spiritual values, and other areas of concern to many people. Commodity production will continue to be important, but it will not always be the dominant reason for managing the land.

In the past, amenity values were emphasized where no commodity values existed and management of amenity values was largely limited to support of commodity production. Ecosystem management allows a broader look at all values and a context in which to measure their importance on their own merits. Human perceptions are very important in this contextual study, since it will be human perceptions that place a higher or lower importance on the various resource conditions or outputs. Responsible resource allocation decisions must be based on fully integrated interdisciplinary team efforts that recognize the full physical, biological, and human consequences.

The Human Dimension Task Team has proposed a human dimension principle of ecosystem management for inclusion in the formal statement of Ecosystem Management principles:

"People are part of ecosystems and human conditions are shaped by, and in turn, shape ecosystems. People value or desire a broad spectrum of

benefits (including survival) from ecosystems. In order to make effective ecosystem management decisions, the Forest Service must have a scientifically sound and integrated understanding of the physical, biological and human dimensions of ecosystems. The human dimension of ecosystem management must include information about people's traditional and changing perceptions, beliefs, attitudes, behaviors, needs, values, and the past, present and possible future influences of humans on ecosystems."

--A proposed Ecosystem Management principle (3/25/93)

Ecosystems have three interrelated dimensions: the physical (landforms, minerals, geology, etc.), the biological (plants, animals) and the human dimension (social, economic, spiritual, cultural, historic, etc.). The essence of sustainable ecosystem management is the balancing of all three dimensions to produce what people want while not preempting the options of future generations needlessly. The Forest Service has considerable expertise in all three dimensions of the ecosystem management concept. However, while there are thousands of people working on the physical and biological dimensions, considerably fewer are working on the human dimension. Those involved in the "hard sciences" have traditionally viewed the social, cultural, spiritual, economic, ethics, and other components of the human dimension with some skepticism. The public, however, increasingly emphasizes the human dimensions as clear expressions of ecosystem values.

It is crucial to understand the potential difference between human perception (in this case, public perception) and "scientific" facts on which management decisions have been traditionally based. Our publics' perceptions are based on many different sources ranging from scientific findings, to media reports, and to religious and/or cultural values. These perceptions must be recognized, considered and reflected in policy and management decisions if all components of ecosystem management are to be truly ecologically and socially sustainable. We must recognize that amenity values cannot be considered as secondary to commodity values or the "hard sciences."

These growing public concerns, along with legislation that requires public involvement in resource allocation and management processes, have led the Forest Service to adopt a sustainable planning process that lists "identification of public issues and concerns" as the first step. This contrasts sharply with the old "scientific model" of management (adopted early by Gifford Pinchot) which relied primarily on the technical judgment of professionally trained resource managers. The model worked well in the early Forest Service when the Agency's activities revolved mainly around watershed protection, firefighting, lumber production, and livestock grazing. But as demands for amenity uses both grew and expanded, and public concerns for environmental protection also expanded, the public wanted to be more involved in the "scientific management" process.

It is also important to understand that both ecological systems and human systems are in reality the same system; they are interdependent, dynamic and evolving together, as is the state of the knowledge about each. Incorporating spatial scales and temporal variation into the characterization of the human and physical/biological components of ecosystems is crucial for advancing understanding of ecosystem management.

This paper describes in some detail the human dimension components and how they might be understood and applied in Ecosystem Management.

II. THE CONTENT AND METHODS OF HUMAN DIMENSION INVENTORY AND ANALYSIS

Natural systems, human habitats and social lifestyles are closely intertwined and are evolving together. They cannot be divided into compartments and analyzed separately. Any approach to describing, studying, evaluating and managing ecosystems must give equal consideration to human dimensions, along with biological and physical dimensions. Indeed, human dimension expertise must be a full partner at the ecosystem management table and throughout the process for all dimensions to be effectively incorporated in the decisionmaking process.

Human Dimension Classifications

The human dimensions of ecosystems are easily identified, but they are not so easily defined and made an operational part of National Forest ecosystem management. The Human Dimensions Task Team has identified six human dimension classes/types of information relevant to sustainable ecosystem management, monitoring and evaluation: History, Resource Character, Social Situation, Managerial Situation, Demands and Needs, and Effects. Each is defined below:

History: Written and archaeological history and prehistory of ecosystems, management units, areas, and sites, including evidence of prehistoric human existence and activity.

Resource Character: Human perceptions of the condition, utility, appearance, or function of ecosystems and land units. (e.g., what is appealing to people?)

Social Situation: Existing social conditions including human benefits, values, traditions, subsistence, myths, religious beliefs, cultures, special interests, economic and social dependencies, demographics, and transportation or other human modifications to natural systems that are an integral part of human society.

Managerial Situation: Management systems, mandates, authorizations, technologies, philosophies, values, constraints, plans, goals, decisionmaking, or other aspects of management process that are related to ecosystem management.

Demands and Needs: Generally demands and needs include commodity, non-commodity, and appreciative demands and needs. While some of these demands are expressed through economic markets, many others are expressed in more indirect ways, such as political structures, on-site use patterns, organizational memberships, environmental education, and the viewing of scenery. Demands are derived from the values, traditions, and dependencies that people attach to natural resources and the ecosystems of which those resources are a part. (It is recognized that demands and needs are a special category of social situation deserving separate treatment because of the obvious implications for management responsiveness.)

Effects: Effects include the results (both negative and positive) of direct and indirect social, economic, and resource interactions (including cumulative effects). As the term "interaction" infers, effects are both from humans upon the ecosystem and from the ecosystem upon humans. For instance, how is the human dimension affecting water quality?

Within each of these classifications are specific data elements and measures that are needed to fully describe and analyze the human values and activity surrounding and interacting within ecosystems. As in the study of ecological systems, when considering and measuring elements within human dimensions, carefully defined and scientifically valid concepts, measures and methods should be used. Effective incentives, rewards and consequences must be in place for resource managers to carry out ecosystem management. There is also a clear role and need for expanded research and management partnerships for improving our understanding of and technical capability for more directly including human dimensions in ecosystem management.

Identification and Definition of Data Elements

This subsection presents the relevant elements that define and make operational the six classes of human dimension information needed for sustainable ecosystem management. Under each of the six human dimension classifications are listed data elements defining each classification. The task team considered these data elements as important social information for ecosystem management. The actual use of these data elements would depend on the ecosystem management questions being asked. An asterisk ("*") preceding a data element denotes that the element is judged to be mappable. Note that individual data elements may be mappable at various spatial and temporal scales-- similar to many of the physical and biological dimension elements. Each human dimension element is listed within the classification with which it is most closely associated but multiple listings are possible and perhaps desirable. Also note that mapping is but one analysis tool - others exist.

NOTE-- definitions of these data elements are being developed and will appear in later versions of this paper.

History

- * Historic landscapes
- * Prehistoric landscapes
- * Traditional cultural areas
- * Past land use history
- * National and local Heritage Sites
- * Past human actions and impacts
- History of the area
- * Management history
- * Cultural Ecology
- Eco-archeological data (past climates, environment, etc.)

Resource Character

- * Landscape variety
- * Landscape desirability
- * Landscape distance zones

- * Landscape sensitivity
- * Existing landscape character
- * Existing infrastructure (roads, rails, etc.)
 - Access to energy and water
- * Health factors (floodplains, smoke, etc.)
- * Attributes of the physical setting
- * Visual character and quality (VQO)
 - Accessibility
- * ROS classification

Social Situation

- * Social institutions
- * Dependent communities
- * Economic diversity and other conditions
- * Transportation corridors
- * Economic market areas
- * Ethnic identities
- * Area population
- * Destination areas
- * Physical developments
- * Demographics (age, sex, income, race)
- * Birth rates
- * Adjacent land uses
 - Informal and formal power structures
- * Subsistence Uses
 - Cultural values
 - Religious/spiritual values
 - Community power structure
 - Public knowledge about ecosystems
 - Environmental ethics
- * Destination areas
 - Disenfranchised, under-represented, under-served populations
 - Political influences
 - Interest groups
- * Universal Access

Managerial Situation

- * Information sources
- * Information delivery systems
- * Interagency coordination
- * Public partnerships and volunteers
 - Public involvement and participation
 - Management models, optimization, conflict resolution
 - Land management culture
- * Private Property Rights
- * Adjacent Land Uses
 - Social mitigation
 - Monitoring and evaluation
 - Agency reflecting the diversity of the public
 - Empowerment
 - Environmental ethics
 - Shared values and philosophies

- Mandates and authorizations
- Budgets and obligations
- Concern with how taxpayer dollars are spent
- Tools, methods and other management technologies
- Political environment
- * Forest plans and desired future conditions

Demands and Needs

- * Subsistence uses
- * Recreation uses
- * Special places
 - Escape from civilization
 - Economic sustainability
 - Economic livelihood
 - Expectations
 - Spiritual renewal
 - Access for people with disabilities
 - Lifestyle sustainability and potentiality
 - Community stability
 - Religious values
 - Attachment to place
 - Preferences
- * Infrastructure needed for ecotourism and heritage tourism
 - Product consumption

Effects

- * Customer satisfaction and activity spectrum
- * Economic impact
- * Present and expected future human impacts
 - Community stability
 - Global survivability
 - Quality of life
 - Legacy and options for the future

Analysis and Display of Human Dimensions Data

As we gain more experience with the use of social data in conjunction with biophysical data, much greater understanding of the relationships these data represent will evolve. Too often biophysical and social data are seen as existing in separate spheres of managerial and research concern, when in fact, they are interrelated and must be considered in an integrated manner as we manage ecosystems. The March 1993 update of the ECOMAP Team's (a task team chartered under the Forest Service Washington Office Ecosystem Management Interdisciplinary Team) efforts to better define the metric aspects of ecosystem management indicated that some NFS regions have established ECOMAP Teams while others have established IDT inventory teams. ECOMAP noted that these teams "include soil scientists, foresters, geologists, hydrologists, ecologists, information specialists, and biologists." The social sciences are conspicuously missing. However, since human dimensions and biophysical dimensions occupy the same space and time, they interact to define the singular system which we refer to as an ecosystem. If biophysical and social dimensions

are not in reality divided into compartments, why should they be in management and research?

A March 1993 WO independent review of how well the human dimension perspective is being used in ecosystem management efforts at the Forest Service Regional Office level discovered few effective efforts to fully incorporate the human dimension with the substantial biological and physical efforts already underway. The people involved in the physical and biological efforts are generally not opposed to adding material on the human dimension but cannot or will not take on the extra work. Therefore, if people with social science skills are not involved directly in ecosystem management, it appears that ecosystem management will not adequately consider the human dimension.

An inventory of the relevant biophysical and social data elements is needed for a comprehensive appraisal of ecosystem relationships. Typically, inventories include mostly, if not exclusively, biophysical data elements. A broader definition of ecosystems and its components is needed and should include the human dimension and social data elements. Inventories of ecosystems and their condition should include the social context, recreational uses, human dependencies, special places, and other dimensions of human history, current situations and demands. Comprehensive inventories and indicators of condition will become increasingly critical as this country's population continues to grow and to become more diverse, and the human pressures on natural systems increase.

Human Dimension Spatial Scales and Relationship to Ecosystem Scales

The ECOMAP Team has defined a hierarchy composed of four levels for defining ecosystems-- Ecoregions, Ecosubregions, Landscapes, and Land Units. Fisheries biologists, hydrologists and geologists are developing more specialized classification systems for their resource areas. Similarly, proposed below is a Human Dimension spatial classification system and hierarchy. The relationship between the biophysical and human dimension hierarchy and scales is explored and displayed below.

Human Dimension Hierarchy and Scales The National Hierarchical Framework (Forest Service, Revised 1/6/93), specifies the following median ranges of map scales associated with the levels of ecosystem classification resolution:

Ecoregion	1" = approximately 20.0 mi.
Ecosubregion	1" = approximately 12.0 mi.
Landscape	1" = approximately 1.2 mi. (Forest Visitor Maps)
Land Units	1" = approximately .33 mi. (USGS QUAD Maps 1:24000)

Uncertainty exists concerning how well these scales coincide with scales relevant to human activities, values, uses, and needs as defined in the section above. The Human Dimensions Team has defined the following scales recognizing that the space defined by these scales is superimposed upon the same land and water areas as the ecoscales above. How well do they fit?

Human Dimension Scales

External to the National Forests

International	Global and continental including two or more national boundaries
National	Confined to the political boundaries of only one country or nation
Regional/Subreg.	Political and/or managerial areas within a national boundary defined on any basis, including physiographic or ecosystem distinctions
Market area	Zone surrounding a human defined management area (e.g., a national forest or district) within which commodities, services, amenities or other resource outputs from the defined area are in demand or are consumed - scales can vary widely. International to local
Local influence	Zone surrounding a defined management area within which community dependencies and social and economic impacts are realized.

Internal to the National Forests

Management Unit	An area defined by a land management agency or other political entity for administration of a legislatively mandated management policy and philosophy
Landscape/Setting	An area defined by both biophysical and human perceptual attributes within a management unit which emphasizes a set of uses, practices, and values tied explicitly to the resource character and capacity extant within the landscape or setting.
Site	A stand, mine, reservoir, developed recreation site, special place, grazing permitted area, or other area defined by one or more special interests.

The approximate juxtaposition of the ecomap and social scales is as follows:

ECOMAP SCALES	SPATIAL DIMENSION	HUMAN DIMENSIONAL SCALES
-----	100s of miles to global	International
-----	100s of miles to nat'l	National
Ecoregion	100s of miles to reg'l	Regional/Subregional
Ecoregion	Roughly 1 to 500 mi.	Market Area (varies widely)
Ecosubregion	Roughly 1 to 50 mi.	Influence Zone
Ecosubreg/landscape	Roughly 20K to 2M ac.	Management Unit
Landscape	Roughly 100s to 20K ac.	Landscape/Setting
Land unit	Roughly 1 to 500 acres	Site

Integrating Social Data and Analysis into Ecosystem Appraisal and Management

Successful integration of human dimensions into ecosystem management, Forest Planning and NEPA project analysis is signified when the "line" between biophysical and social data blurs to the point of becoming indistinguishable. The relevant question for appraisal of the condition and potential of ecosystems then becomes which data are relevant to the questions, issues, management options, or any other objectives that are being considered.

The first phase of ecosystem appraisal is to identify the question (issue, concern or need) which is initially mandating the appraisal. The question can range from a general Agency policy to do an appraisal of the health, condition and situation of all ecosystems on national forests, to a more specific question about the production possibilities for a specific output at a specific site, e.g., dispersed recreation. Careful definition of the question will easily lead to the identification of which biophysical and human dimension characteristics of an ecosystem and its setting need to be described and analyzed.

In such analyses for sustainable ecosystem appraisal and management, some data elements within all of the six human dimensions identified earlier-- history, resource character, social situation, managerial situation, demands and needs, and effects-- are likely to be relevant. The scale(s) at which these data elements are relevant will depend on the scope of the question or mandate being addressed (from local, site-specific questions to questions of international significance). The scales at which human dimensions are analyzed should, then, coincide with the scope or level of significance of the ecosystem question or issue being addressed.

Analysis and presentation for the ecosystem appraisal can be organized as follows:

1. Identify the question and the scales relevant to the question, and area or site.
2. Inventory the relevant biophysical and human dimension attributes to include internal (National Forest level) scale attributes, but also attributes or characteristics at influence zone, market area and other relevant external scales.
3. Describe the conditions, status, trends and values important to deciding the ecosystem question with human dimension data integrated into the analysis.
4. Define Forest Plan desired future conditions based on both biophysical and social analyses.
5. Identify and define appropriate management strategies and predict likely direct and indirect outcomes and tradeoffs from implementation of these strategies.
6. Establish monitoring and evaluation processes, and adaptive management systems to consider all aspects of the biophysical and human dimensions relevant to the situation.

GIS and Mapping as Tools of Analysis

In the section above, which identified and defined the six human dimension classifications, data elements with known mapping characteristics were identified. Key to widening the acceptance and integrated use of human dimension data in ecosystem management is convenience, cost, simplicity and the ability to see relationships of social characteristics to biophysical characteristics. Geographic Information System (GIS) technology provides this simple, yet very powerful, capability.

While biophysical data may be captured and displayed at scales and levels of resolution different from those relevant to human dimensional data, differential levels of amount, intensity, quality, recency, etc., of both sets of data may be spatially described, displayed and superimposed. This superimposition provides the manager, scientist and public a visual representation through mapping for seeing system relationships, potential conflicts, and complementary relationships. At some scale, all human dimension data are "mappable." For broad public attitudinal data, the influence zone or even market area may be the lowest level of resolution possible. But across population areas within influence zones and market areas, differences in gradient may be distinguished and displayed relative to relevant atmospheric, climatic, soil, water, and biological dimensions. Other tools will also be needed - maps won't do it all.

Currently Available Data and Methods

Following is a brief listing and description of some of the available human dimension data-- these examples relate to many of the human dimension data elements in the classification lists.

Recreation Visitors In cooperation with Forest Service Research, NFS routinely collects and analyzes data describing the demographics, preferences, attitudes, values and economic impacts of forest recreational visitors. OMB-approved surveys of wilderness users through the Intermountain Station and through the use of CUSTOMER, CUSTOMER Report Card, and CUSTOMER Comment Card are examples.

Recreation Use The Forest Service and other agencies routinely collect information describing the incidence, amount, type and location of recreational use of forest areas (Recreation Resource Information System - RRIS). These data can be associated with ecosystem delineations.

General Public -The National Survey on Recreation and the Environment (NSRE) is underway to collect information on the U.S. public's participation in outdoor recreation, and on attitudes toward management issues, accessibility issues, wilderness and wildlife. The USDI Survey on Hunting, Fishing and Nonconsumptive Wildlife Activities is another example. These and similar surveys are scientifically valid data sources and are OMB-approved to provide subregional resolution.

Anecdotal Data Newspapers, demographic magazines, other media and generally published materials provide a wealth of information and data on public attitudes, trends, and concerns, and on new issues in resource management.

Census and other Secondary Sources Census of Population, Census of Agriculture, business indicators, labor statistics, opinion polls, and a host of secondary source data help define the social climate within which ecosystem management and appraisal reside.

All of the above data sources are available at low or reasonable costs for developing a human dimension baseline and for monitoring change. Used in conjunction with GIS, these data form a powerful basis for increased understanding of the human dimensions of ecosystem policy, management and use.

III. THE CURRENT SITUATION

The broad implications of adding the Human Dimension as a full partner in the sustainable ecosystem management effort may seem daunting to many people who have been focused on the physical and biological dimensions. Please be reassured; the Agency is not starting from zero. A small but active group of Forest Service research social scientists is exploring the vast amount of social science research information, while also doing original Forest Service-related research. In addition, each Regional office has a Social Science Coordinator. The Washington Office Environmental Coordination office has a social scientist on staff, as does the RPA staff. A scattering of social scientists do exist at the Forest and District levels (including archeologists, anthropologists and sociologists). Forest Service social scientists also include more than 75 economists. In addition, many employees in Recreation, Heritage Resource, Wilderness, Wildlife and Public Affairs have formal education in social sciences and are very much involved in the human side of ecosystem management.

Is the Forest Service human dimension cadre large enough to do the job ecosystem management demands? That remains to be seen.

Ecosystem Management Incorporating the Human Dimension: Examples

It was very difficult to find existing examples of ongoing efforts that fully integrate all the dimensions of ecosystem management. It was easier to locate examples of some parts of the human dimension being used in conjunction with a part of another dimension. We are sure more fully integrated examples exist.

Many ecosystem management projects are being undertaken around the nation and many include at least some consideration of the human dimension in ecosystem management. How and on what scale the human dimension is considered varies from study to study, and a range of questions may need to be addressed. For instance, we may need to assess how the public perceives uses of NFS land today, and compare this to how it perceived uses 10 years ago. How does the public think lands should be managed now? How have economic conditions changed? What are peoples' needs now? What is their "sense of place" for a study area? What influences did prehistoric peoples have on a landscape? What about historic influences?

Our goal is to manage public lands by using an ecological approach in our implementation of multiple-use management. The needs and wants of people as well as the physical and biological dimensions of ecosystems will be equally considered in decisionmaking. To be fully effective in ecosystem management we must consider how we are and have influenced the physical and biological

components of the environment and how we have been and are now influenced by the environment.

The following are a few examples of how considerations of the human dimension have been applied in recent Forest Service projects.

Western Montana Grizzly Bear Issue Study

The United States Fish and Wildlife Service (USFWS) has an ongoing study of the grizzly bear population and available corridors for their migration between the Mission and Swan mountain ranges. The bear was once relatively free to move between these two mountain ranges, to reproduce, and to keep safe distances from humans. However, conditions in the Seeley-Swan valley, which separates the two mountain ranges, have changed drastically. The area is now enmeshed in a "checkerboard" pattern of state, federal, private and residential ownership. This rural and rather remote area has seen its human population increase significantly. Much of the economy is based on timber and tourism, and many vacation residences exist. In other words, the people and the bears live in close proximity. The combined effects of demographics, zoning, social conditions, and economic conditions cause the bears to be limited to four narrow biological/travel corridors. The viability of the bear, its habitat and mobility cannot be considered without a clear understanding of both the bear and the humans who inhabit the area.

Human dimension data elements being considered include: social values, public involvement strategies, economic analysis, settlement patterns, fire history, and people's values in respect to the bear.

Abandoned/Inactive Mining Claims: Deerlodge N.F.

Over 900 abandoned or inactive mining sites exist on the Deerlodge National Forest near Butte, Montana. Of those sites, 605 are CERCLA sites. Of those, 96 are problem sites, 35 are mill sites and one is an old smelter. A number of ecosystem questions are posed by this situation. The human history of the mining in this area-- understanding where the mines are, what was mined, methods used, etc., is a critical component of understanding the physical environment to be managed. Consideration of past human actions and examination of what resulted can assist in solving contemporary natural resource problems.

Historic Records Used to Reconstruct Ecological Conditions: Michigan

In northern Michigan a study of mid-19th century General Land Office survey records, in conjunction with current ecological plot data, has been successful in formulating an environmental model that provides a context for the historical presence of certain ecological conditions and previous human disturbance of the forest landscape. This information is being used to substantiate the potential natural forest vegetation composition for future landscape restoration. For instance, in the Raco San Plains, large openings and savannah ecosystems are needed to provide habitat for several wildlife species, including the sharptail grouse and a number of neotropical bird species, such as the threatened Kirkland's warbler. Years of fire suppression have resulted in a reduction of naturally occurring large openings and the existence of a pine dominant ecosystem in the area. Studies of the GLO record

indicate an historically open forest composition compared with the currently dense stocking of red and jack pine. This documentation has provided baseline data which supports a way to restore historic habitat characteristics and potential natural community features of a fire-maintained ecosystem that existed prior to the era of accelerated logging and fire suppression activity.

Social assessment: Blackfeet Indian Tribe

A social assessment, also called a perception study, was undertaken on the Montana reservation and surrounding communities associated with the Blackfeet Indian Tribe. The study added to the Agency's awareness of their culture, lifeways, beliefs, traditional cultural practices, and social and political organization. The Forest Service was able to learn valuable information which has contributed to more effective communication between the tribe and the Agency, and to making sound and reasoned decisions.

Forest Service Research Activities Related to Human Dimensions

The significance of the relationship between people and the environment to sustainable resource stewardship is recognized in a wide range of recent research-related management and policy documents (c.f. National Research Council, 1990; Consortium for International Earth Science Information Network, 1992; Salwasser, MacCleery, and Snellgrove, 1992; Sample, 1991). (See Appendix for complete references.) Having recognized the significance of the human, physical and biological dimensions of ecosystem management, the next issues to be addressed include: (1) what does the relationship between people and the environment entail and (2) how can it be incorporated into sustainable resource stewardship. As the Agency approaches these issues, the question becomes "what is the human dimension of Ecosystem Management and how can it be integrated into forest management?"

Many Forest Service research projects and scientists are exploring these questions. The following is a review of issues addressed by Forest Service Research relevant to the human dimension of Ecosystem Management.

Recreation and Wilderness

The longest-standing areas of research related to the human dimension of resource management are those related to recreation and wilderness uses. Research topics include the benefits of leisure and recreation, visitor profiles, preferences, and satisfaction, impacts on the resource due to visitor use, and trends in visitor use and activities.

Ethnic Diversity and Urban Forestry

Closely related to recreation research, this area focuses on the increasingly urban and diverse publics using and concerned about forest lands. Issues being addressed include the preferences and needs of ethnically and racially diverse recreation customers and values held toward natural resources by urban and/or rural residents.

Rural Development

The 1980's brought attention to the plight of rural America. In an attempt to address issues related to the relationship between the Agency and rural communities, Forest Service Research developed a research strategy, "Enhancing Rural America." Research focuses on understanding the impacts of land management decisions on communities, on the economic and social impacts of tourism on rural communities, and on diversifying rural economies.

Relationship Between People and Natural Resources

This is a focus area for Forest Service Research and is of increasing importance. Since 1973, research at the Rocky Mountain Station has focused on the values and benefits of amenity goods and services and has resulted in many products currently in use today-- Recreation Opportunity Spectrum and Benefits Based Management, for instance. Three recently established efforts that have direct implications for the human dimension of ecosystem management include the creation of two new research work units: the Social and Economic Dimensions of Ecosystem Management unit, and the Integrating the Ecological and Social Dimensions of Forest Ecosystem Management unit. Additionally, social research done at the Pacific Northwest Research Station is part of the Consortium for the Social Values of Resource Management. Many other research projects are turning their attention to human dimensions issues.

Legislation Review - Human Dimension focus

A summary of selected references to authorities or enabling legislation that currently provides for, requires, and/or recognizes the important role of the human dimension in Agency activities and decisions. Note that explicit references to elements of the human dimension have been in Agency-related legislation for a long time.

While the term "human dimension" does not appear as such, it is implicit in the specific references to cultural, social and/or economic well-being; community welfare, people, the public good, etc.

The 1990 Farm Bill (Title 23, Subtitle G--Rural Revitalization through Forestry) and other laws, regulations, and policy give the Agency direction to participate in community-based rural development activities.

The National Forest-Dependent Rural Communities Economic Diversification Act of 1990 (provided for in the above Farm Bill subtitle) provides the Agency with a special opportunity to help eligible rural communities located in or near National Forests to organize, plan and implement rural development efforts.

Weeks Law (3/1/11) authorizes the Secretary of Agriculture to provide fire protection on State and private lands tiered to watersheds. Also authorizes the Secretary to sell or exchange Forest Service lands to States where it was in the public interest to do so.

Twenty-five Percent Fund Act (5/23/08) authorizes the Secretary of Agriculture to extract 25 percent of timber and other forest products receipts from that area in which the timber came to provide for public schools and roads for those counties in which the Forests are situated.

Townsite Act (7/31/58) authorizes the Secretary to set aside and designate as a townsite up to 640 acres for indigenous communities adjacent to public lands, where community objectives outweigh public objectives and values.

National Historic Preservation Act (1966)

Alaska National Interest Lands Conservation Act (1980) - Title VIII contains specific provisions to ensure economic, social and cultural needs of rural Alaskans are cared for.

National Environmental Policy Act (1969) is the nation's basic charter for protection of the environment. NEPA's main thrust is evident in its preamble: (a) to encourage productive harmony between people and their environment and to (b) prevent or eliminate damage to the environment...and stimulate the health and welfare of people. NEPA requires the interdisciplinary use of the natural and social sciences in Federal planning and decisionmaking which may affect the human environment (Sec. 102(2)(A)). Section 101 authorizes "all practical means to foster and promote general welfare...and create conditions...where man and nature can exist in productive harmony...to preserve important historic, cultural, and natural aspects of our national heritage...and maintain an environment that supports diversity and variety of individual choice...An important aspect of NEPA is that it can serve to coordinate consideration of...other environmental statutes..."

Forest and Rangeland Renewable Resources Planning Act of 1974 requires the public interest to be served by the Forest Service. As such, the renewable resource program must be based on a comprehensive assessment of present and anticipated uses, demand for, and supply of the renewable resources from the nation's public and private forests and rangelands. It declares both a responsibility and opportunity to ensure and maintain a conservation posture that will meet requirements of our people in perpetuity.

The Cooperative Funds and Deposits Act (12/12/75): Gives authority to the Secretary of Agriculture to negotiate and enter into cooperative agreements with...other agencies, organizations, institutions...when [he] determines the public interest will be benefited and there are mutual interests.

Federal Land Policy and Management Act of 1976 gives authority to the Secretary of Agriculture to dispose of public lands, through exchange, when determining the public interest would be well served in so doing. Describes multiple use as means of managing lands and resource values so ...as to best meet present and future needs of the American people.

National Forest Management Act of 1976 amended the 1974 RPA. The NFMA states: "...to serve the national interest, the renewable resource program must be based on comprehensive assessment...through analysis of environmental impacts...the Agency has the responsibility and opportunity to be a leader ...to maintain natural resource conservation posture to meet the requirements of a people in perpetuity."

Cooperative Forestry Assistance Act of 1978 gives authority to the Secretary for financial, technical, and related assistance to State Foresters or equivalent State officials to further provide technical information, advice and

related assistance to private landowners, etc., in management assistance, insect and disease control, rural fire protection, and rural forestry.

IV. CONCLUSIONS - WHERE DO WE GO FROM HERE?

Much needs to be done before the human dimension is a full partner in ecosystem management. The Agency needs to decide it is important to include the human dimension. Indeed, a commitment to this importance has been expressed by President Clinton (Forest Conference - 4/2/93) and a number of the Agency's top leadership-- we must follow through and meet the commitment. Management questions need to be formulated to assist in identifying what types of information are needed. Appropriate levels of professional staffing and funds will have to be determined and provided. Analysis tools and integrated information inventory processes, including map layers, scale analysis, and GIS, will need to be developed. Finally, research is needed to develop an understanding of how the human dimension layers relate to the other dimensions of ecosystems. An effective interdisciplinary team process will focus on identification of tradeoffs and other implications involved in managing ecosystems. When coupled with full public participation, Forest Planning and adaptive management, this information will set the stage for the Forest Service to better manage the invaluable resources it is responsible for.

Human dimensions must be an integral part of ecosystem management, not a footnote.

"People are part of ecosystems and human conditions are shaped by, and in turn, shape ecosystems. People value or desire a broad spectrum of benefits (including survival) from ecosystems. In order to make effective ecosystem management decisions the Forest Service must have a scientifically sound and integrated understanding of the physical, biological and human dimensions of ecosystems. The human dimension of ecosystem management must include information about people's traditional and changing perceptions, beliefs, attitudes, behaviors, needs, and values, and the past, present and possible future influences of humans on ecosystems." - A proposed ecosystem management principle (3/31/93)

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TEAM MEMBERS

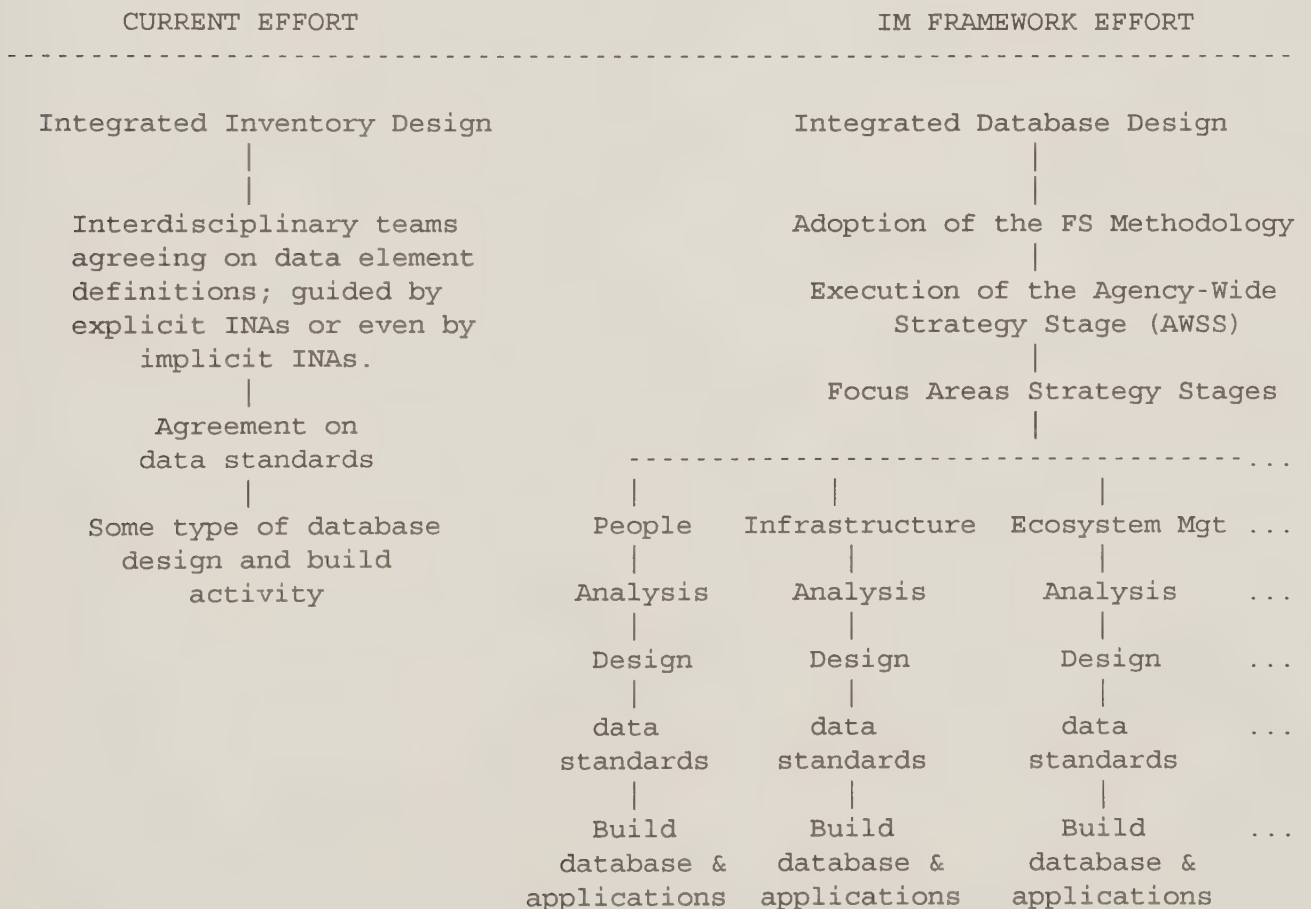
G.Super:W01C - Washington Off., Recreation, Cultural Resources & Wilderness
S.Yonts-Shepard:W01C - WO - Legislative Affairs
G.Bower:W01C - WO Environmental Coord Staff
V.Chambers:W01B - WO Public Affairs
D.Carr:W01C - WO, Forest Inventory, Economics & Recreation Research
J.Osborn:W01C - WO - Recreation, Cultural Resources & Wilderness
B.Driver:S28A - Rocky Mtn Station - Valuation Of Wildland Resource Benefits RWU
K.Cordell:S29L01A - SE Station - Outdoor Rec. and Wilderness Assessment RWU
G.Flora:R04F03A - R-4 - Bridger-Teton NF - Resource Ecology
H.Mittmann:R02A - R-2 - Recreation, Wilderness, Cultural and Lndscape Arch.
S.Galliano:R08A - R-8 - Recreation
W.Bacon:R06C - R-6 - Recreation
C.Manning:R01A R-1 - Land and Financial Planning

ISSUE PAPER 1 - INTERGRATED INFORMATION STRUCTURE

A. Using Business Modeling to Better Organize Our Inventory Integration Activity

Several of the responses, to questions 1, 3, and 7 of the questionnaire sent out in preparation for this workshop, expressed the realization that accomplishing ecosystem management entails complex information management. The agency has found it necessary to relate or integrate it's functional information just at the point it's been directed to dramatically increase the amount of information it tracks.

A companion realization expressed was that many of us are doing many things to try to catch up with this integration/tracking need but there's a sense that what we're doing is not well thought out, not adequate to the task, and wastefully redundant. So how can we do better? Several of the responses mentioned that the Chief's Strategic Information Management Task Force report titled, "Information Management: A Framework for the Future", provides a national level umbrella for taking on this challenge. Let's compare what we're doing now with what we might be doing under the Information Management (IM) Framework:



The diagram makes some points. People talking about integrated inventory design (using "inventory" as a noun) and people talking about integrated database design are talking about essentially the same thing. But the

approach being taken by people trying to integrate inventories is less formal than the approach being taken by people focusing on integrating databases. The latter are using the FS Information Engineering Methodology. The methodology's purpose is to provide a systematic approach to developing business systems where a business system is defined as a blending of manual and automated processes to accomplish some job. The methodology emphasizes use of several models (e.g., data model, function hierarchy, data flow model, process flow model, data/function cross-reference matrix, etc.) which collectively are called business models. These are built to help understand the requirements of the needed business systems and furnish the blueprint from which integrated systems can be constructed. In our case the business systems could be those needed to accomplish the job of building and maintaining an integrated resource inventory or more generally, to accomplish integrated resource management. See Exhibits 1. and 2. for examples of a data model and a function hierarchy model taken from Region 10's Integrated Resource Inventory strategy study.

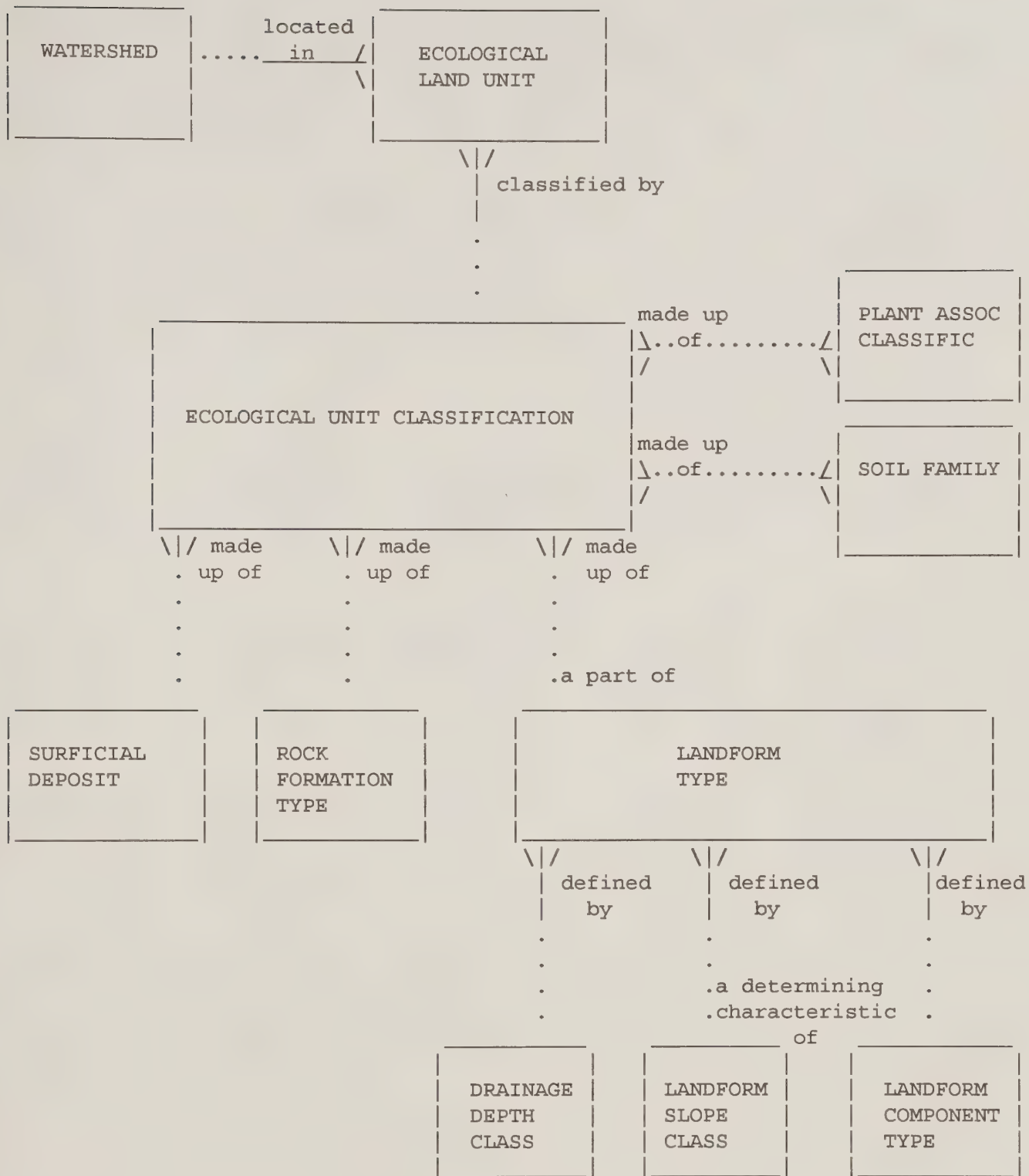


Exhibit 1.
TERRESTRIAL ECOLOGICAL UNIT Data Model

legend:/ a one-to-many, "may be" relationship
 \ / a many-to-one, "must be" relationship

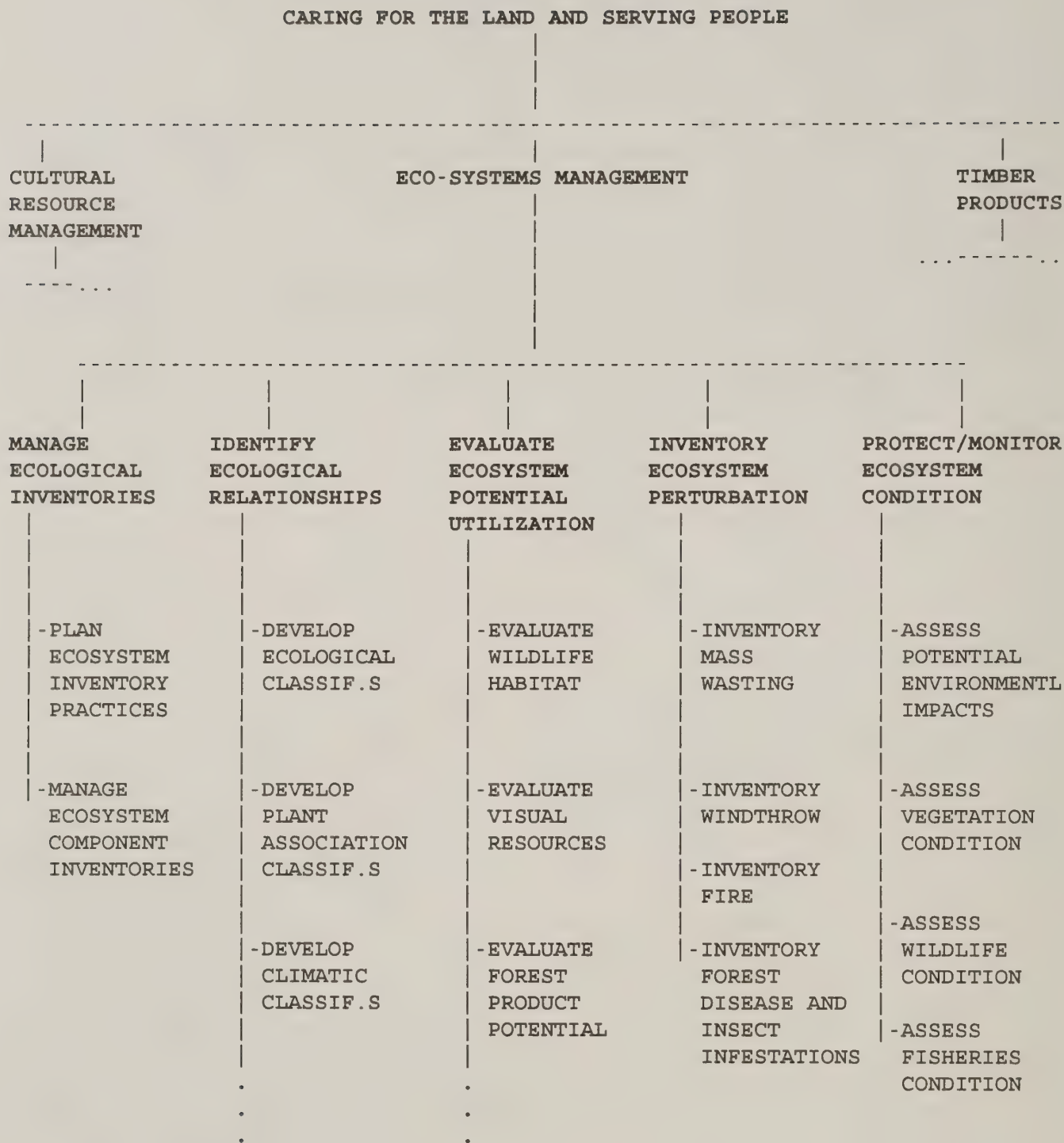


Exhibit 2.
ECOSYSTEMS MANAGEMENT Functional Hierarchy

The goal of the methodology is to get the right information, in the right form, at the right time, to the right people, to support sound and deliberate decisions and to generate ideas (IM Framework). It encompasses 7 sequential stages; Agency-Wide Strategy, Focus Area Strategy, Analysis, Design, Build/Document, Transition, and Production. That list looks long and heavy on analysis, and it is. But remember, a key feature of the challenge facing us is its complexity. Meeting the challenge is going to require careful thought and a rigorous approach.

Conducting the Agency-Wide Strategy Stage (AWSS) has been approved by Chief and Staff and is scheduled to begin this month or next. The two major products to be delivered by the AWSS are the high level FS Business Models and a strategy for dividing up the agency's business system development job into pieces of manageable size. The manageable pieces are called Focus Areas and their boundaries or scope are defined in terms of the Business Models. That is, an analysis of the agency's business requirements, as reflected in the models, is done to determine which requirements are sufficiently interconnected that it makes sense to work on them together. Clearly there is a fair amount of intuition and common sense involved in making these groupings. The models are used to help guide and validate the intuitive reasoning and frequently lead to groupings of requirements which cross-cut many of our traditional functional areas.

An example of such a cross-cutting grouping, and potential Focus Area, is something several FS information engineering projects have called AGREEMENTS. An AGREEMENT is defined simply as an understanding or arrangement between two or more parties to accomplish a common objective. Thus a Personal Service contract is an AGREEMENT. So is a Range Allotment Permit or any Special Use Permit. All Memorandums of Understanding with cooperators and partners are AGREEMENTS. Even our performance elements and standards are AGREEMENTS. This suggests that there might be some very generic business system modules, almost as generic as a word processor or a spreadsheet, which could be developed to support a very wide array of FS business processes. For instance one module might standardize how we record the name, address, and other "contact" information we need for those with whom the agency enters into agreements. And certainly that module would store that data in a database structure accessible to all who need to use contact information. No more multiple mailings of a single thing to the same party; no more double or incomplete counting of the number of respondees on a certain issue. Contrast this to what has been occurring up until now. Each FS function and sub-function has tended to develop its own permitting system and contact tracking system. I'm sure you can think of other examples like these. How many different budget tracking systems do you think we've paid computer specialists to build over the years? The point is that the methodology and business modeling can help us avoid burning up our scarce resources on developing the same things dozens of times.

If it was absolutely necessary to follow the methodology precisely it would not be wise to initiate any Focus Areas until the Agency-wide Strategy Stage had finished and defined them. However, other organizations' experience indicate it's reasonable for us to follow intuition to some extent and to launch some Focus Area strategy stages even before the Agency-wide Strategy Stage has been completed. One potential Focus Area

has been labelled Ecosystem Management. That covers a lot of ground and maybe there are several Ecosystem Management related Focus Areas. Maybe "Integrated Resource Inventory" is a Focus Area as proposed by R10 in their responses to the questionnaire. R2, R4, and R5 all also referred to an IRI project if I remember correctly. In any case it would appear that there are many cross-cutting opportunities to be identified and capitalized upon in the area of Ecosystem Management/Integrated Inventory. Certainly many of the responders to the questionnaire recommended more national coordination, sponsorship, and funding in this area. Of the four small group topics for later today the first involves a further discussion of business modeling applied to the FS resource inventory "business". Region 10 has recently completed a strategy stage for integrated resource inventory. We will be using their models to provide illustrations of the concepts. We will be interested in learning what you think of the methodology approach, whether this much rigor is necessary, whether it should be applied and if so how widely and how aggressively (in terms of timing and funding).

B. National Level Ecosystem Management Information Requirements and A Minimum Set of Geographic Information System Themes/Layers to Support Integration of Inventories

Lets turn our attention now to national information requirements and data standards to support inventory integration. The two are related in that data standards are needed for any information which is required to be shared widely. This is so because, without standardization of the naming and format of the data, it is virtually impossible to roll it up into aggregates to determine conditions and effects at larger scales. The FS methodology provides for the identification and successive refinement of business requirements. This includes, of course, the information required to conduct the business. As business system development moves from the Strategy and Analysis stages into the Design and Build stages the descriptions of the information requirements become detailed enough to constitute data standards.

Typically we understand a data standard to be a definition for a "data element". We are just now reaching consensus on the components of such definitions as demonstrated in FSH 6609.15, Standards for Data and Data Structures. In that handbook the definition of a Term (synonym for data element) is composed of; a) Narrative Description, b) List of Valid Values (or reference to such a list), c) Units of Measure, d) Example, and e) Source for Data Standard. The List of Valid Values includes the encoding of these values if such exists and has been agreed upon by the appropriate group of stakeholders, i.e., people affected by changes to the definition, format, content and/or encoding of this data.

FSH 6609.15 represents the work of several teams of knowledge experts from different FS functional areas. They met for several weeks and months a few years back and reached agreement on what terms were in wide use in their areas and how those terms should be defined. Another group met to develop a structure for organizing these standards in a manner which would provide guidance for identifying a set of themes or layers to be used in FS Geographic Information System analysis. Eighteen themes were identified namely: Vegetation, Ecology, Geology, Topography, Soil, Water, Air/Climate,

Wildlife/Fish, Constructed Features (Transportation), Constructed Features (Utilities), Constructed Features (Buildings/Other), Constructed Features (Developed Sites), Recreation Setting, Historic/Prehistoric, Socio-Economic, Land Survey, Ownership and Jurisdiction, and Restrictions and Rights. FSH 6609.15 uses this set of themes to organize the data standards it contains.

Of the eighteen themes/layers about half are related to information on Primary Base Series maps. It has already been decided that each FS unit using GIS will obtain a set of Primary Base Series data. The remaining ten themes/layers (i.e., Vegetation, Ecology, Geology, Soil, Water, Air/Climate, Wildlife/Fish, Recreation Setting, Historic/Prehistoric, and Socio-Economic) are candidates for the minimum set needed to support FS resource inventory related work.

One of today's small group topics deals with identifying such a minimum set of layers and their composition. By composition I mean which features should be included in each layer and which attributes should be described for each feature. A handout describing the themes, features, and attributes has been provided to assist small groups in identifying the minimum set of themes/layers and their compositions. We leave it to those small groups to recommend how far to go in this direction at this time. One possible weakness in the process used to develop FSH 6609.15 was that it was fairly functionally oriented. Thus the themes it derived and/or their features and attributes may not be as integrated as needed to support integrated inventory. But odds are that most of the themes are good candidates for establishing as in the nationally required minimum for GIS, and many of the features and attributes also have wide applicability and utility.

C. Establishing Common Terminology for Ecosystem Management

Related to information requirements and data standards is the whole question of common terminology or language. The focus here is not so much getting data in a shape to enable it to be aggregated at larger scales as being able to understand what the different players in the inventory community are saying and recognizing those things we have in common. The data standards in FSH 6609.15 contribute to both of these objectives. But so do a whole lot of other glossaries and data dictionaries such as the Interim Resource Inventory Glossary, Regional Data Standard Handbook supplements, the Wildlands Planning Glossary, all the definition (05) sections in the FS Manual and Handbooks, Chapter 70 of the Timber Management Information System Handbook (FSH 2409.14), the attribute portion of the Federal Spatial Data Transfer Standard (FIPS-SDTS), and no doubt many more. As we move away from predominantly functional approaches to resource management should we be making sure this is reflected in the terms we use to describe what we do and the definitions we attach to those terms? For instance, do we need to reduce the amount of functionally specific terms and definitions in our different areas' manual chapters and handbooks wherever more commonly defined terms could serve the purpose? Do we need to consolidate our terminology definitions in a single place such as FSH 6609.15? What procedures might we institute to ensure a continuing effort is made to derive common terminology? Finding answers to such questions is the focus of the third small group topic.

D. What Is the Resource Specialist's Role in Maintaining Information to Quality Standards?

The matter under discussion here concerns recognizing new responsibilities for the resource professional (and in fact the rest of FS employees). Clearly we all are trying to better accomplish the agency's mission by improving the organization of our information, our ability to use it in analysis, and the accuracy of the predictions we make about what will happen on the ground.

But there are indications that we are not going about this in the right way. Again, as indicated in many of the responses to the questionnaire, it appears that our efforts are wastefully duplicated. In part this may stem from a history of treating information as personal property. We've each done what we had to, to get the information needed to do our job. We usually organized it depending on the needs of the moment and kept it wherever it was convenient. Since at least the late 70's federal oversight agencies, such as OMB, have been telling us we've got to move beyond that and start treating information as a corporate resource.

So what does this mean for the Resource Specialists. Here are some ideas for the small groups to begin with and and expand on or refine:

1. Resource Specialists needing data should ask first, "Where can I access this data?", not, "How can I collect this data?". That is they should trust other's data and abide by the ethic "I trust others to guarantee the quality of their data and in return guarantee the quality of the data I create for all of us to do our jobs." If specialists determine the needed data is not available they should not immediately begin an effort to collect it but work with their peers to determine if that kind of data could be captured, in whole or in part, as a by-product of some business transactions. For example, how much timber inventory data could be captured as a by-product of automating certain parts of the fuel wood permitting, timber sale, fire suppression, and other vegetation manipulation processes? Perhaps the need for the data is too urgent to be met with such a long range approach. But some portion of that community of specialists should be freed to devise and put in place such long term strategies. It it will be through such efforts that the IM Framework principles "Data are captured at their source as a natural course of conducting Forest Service Business" and "Data are entered once and used often", will come to be realized.
2. If after a reasonable investigation of the alternatives, a resource specialist does determine data collection is called for then it is incumbent upon them to make a good effort to ensure they have discussed the collection with others who likely would also be able to use it. The point of such discussions would be to agree on such things as collection frequency, methods of measurement, collection of associated data, sampling schemes, etc. How do you tailor such a principle to the day-to-day work environment, e.g., to prevent it from slowing down field work? Caution: gaining quality in our information resource is going to

feel like overhead but is it; and can we afford to try to get by without it?

3. Resource Specialists should function as stewards for collections of data in their area(s) of expertise. Thus the Specialist should take care of various collections of data for the good of all others who could use it. Notice how this moves away from treating information as personal property. It will take up some of the Specialists' time. They may have to help manage access to the data, e.g., by informing a DBA about who should have update as opposed to read only access. They will be responsible for keeping the data current, e.g., as of month end, quarter end, or year end. They will be responsible for fixing reported errors or omissions and will have to involve other stakeholders when suggestions are made about changing formats, coding, naming, definitions and so forth. Will Resource Specialists accept this kind of work and if not how will it get done?
4. Resource Specialists should make themselves available to serve on interdisciplinary teams formed to develop agreement on standard structures for their unit's information, as well as for the agency's information, and maybe even for the public's information.

These data stewardship responsibilities may sound bureaucratic, time consuming, and like barriers to getting the job done. But once they are in widespread practice isn't it reasonable to expect that much time will actually be saved and the job will be easier to accomplish? The small groups have the opportunity to decide if this an idea whose time has come, and if so how to devise ways to get it implemented in the Forest Service.

Summary

To summarize, the responses to the questionnaire suggest that the complexity of integrated resource management begets complexity in the information structures which support that activity. This motivates us to seek the discipline and rigor of a formal business systems development methodology and to employ business modeling to find optimal designs for these information structures. A key output of the methodology and business modeling is identification of agency-wide information requirements and their associated data standards. It is possible to organize subsets of these data standards in layers to support GIS analysis. Stewardship of the data standards and layers, and of the sets of data collected in conformance to their definitions, is needed. This is a job which seems logically to fall to the Resource Specialist. Standardization of terminology is a related need and one that will require cross-functional dialog and cooperation. If we are to succeed in creating and maintaining integrated resource inventories, and thereby in practicing ecosystem management, we will have to devote attention to each of these things.

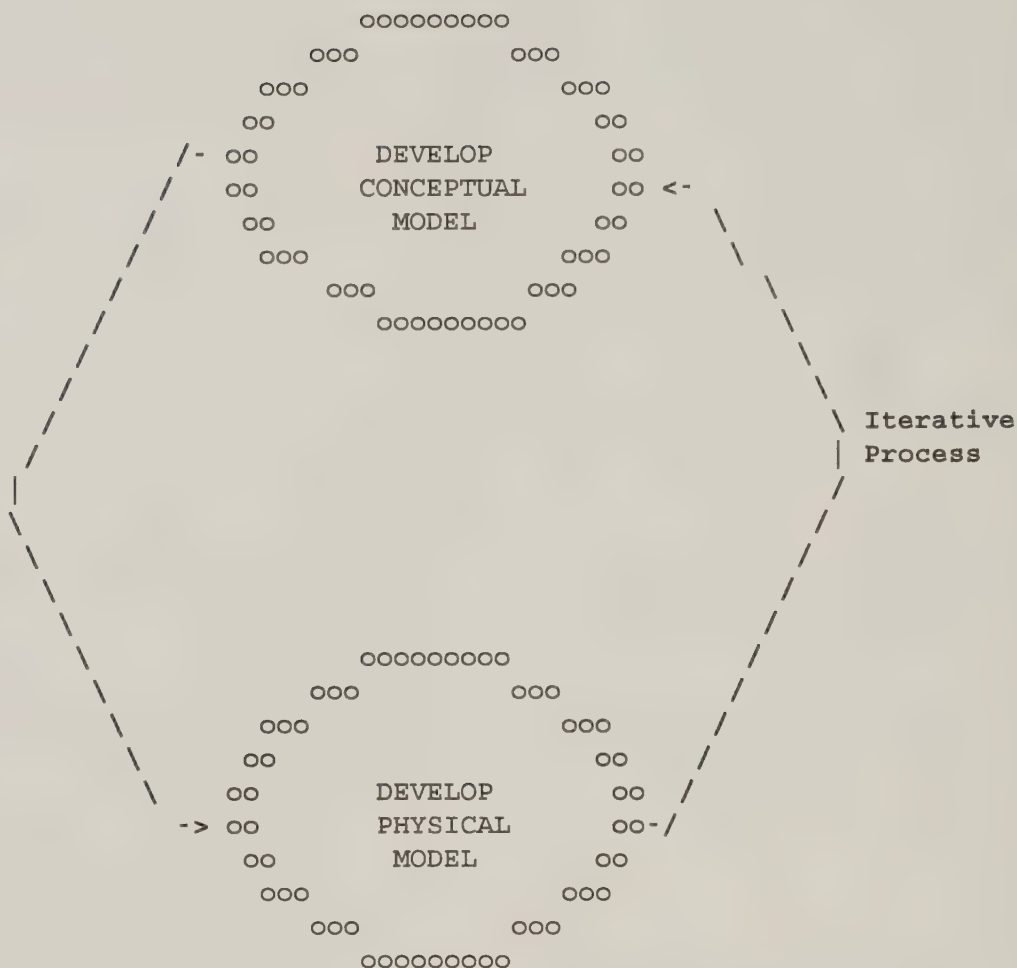
COMBINED RECOMMENDATIONS: Issue Paper 1 - Integrated information structure:

A. Develop a National Standard Business Model for ecosystem management. Use this guide to guide development of a corporate resource inventory data base.

1. We recognize that there have been a number of Integrated Resource Inventory (IRI) efforts going on - all of which have been producing valuable results. However we need a more focused, broad, national effort based upon input of all stakeholders and building on the best of past efforts. In our understanding of the FS IM Framework Methodology we see this as an Ecosystem Management Focus Area. So we recommend that 1-2 representatives from each Region/Station Ecosystem Classification, Inventory, and Mapping (ECI&M) team be formed into a steering committee and commissioned to oversee development of a national standard business model for ecosystem management.
2. We recommend that the following factors be incorporated into the national EM business model:
 - a. Flexibility to allow Region/Station variation - but within a framework of agency and inter-agency standards.
 - b. The model be hierarchically structured with separate business model levels corresponding to the separate levels in the agency's ecological unit classification hierarchy.
 - c. The model should reflect temporal, spatial, and functional (system function) aspects of ecosystems.
 - d. The model should be flexible enough to accommodate point, line, and polygon representation of resource information.
 - e. Data put in the resulting integrated resource inventory (IRI) database(s) must be created/collected using standard methods (to ensure Quality Control).
 - f. The model should ensure sufficient metadata is kept to ensure data quality and enable data sharing.
 - g. Interpreted/derived data is allowed in the resulting IRI database(s) provided measures are put in place to guarantee it is consistent with the underlying basic data.
 - h. The model has to identify the "corporatness" level of each data element, be it agency-wide, region/station-wide, forest/lab-wide, or district/project-wide.
 - i. The model should be built using the FS IM Framework Methodology.
 - j. Implementation of the resulting IRI database(s) will not force all inventory data collection to be done by "integrated inventory teams".
 - k. The model will establish standard processes for analysis and information products (e.g., maps).
 - l. The model will, to the extent practical, foster capturing data as a by-product of business transactions - thereby minimizing, again to the extent practical, raw data collection and separate data entry.
 - m. The national level of the EM (or IRI) Business Model must clearly delineate the business processes and sub-processes needed to accomplish Ecosystem Management at large scales. These must be cross-checked against associated data models to ensure all major business processes have been defined for this level and only needed data is captured and stored for this level.

3. A national level business model is not needed before work can be undertaken on business models for the other levels of the ecological classification hierarchy. Concurrent with the national effort we need an iterative effort to integrate other business modeling activities down the hierarchy. Mechanisms will be established to ensure feedback and testing across the hierarchy. For this amount of simultaneous activity to be accomplished a concerted, facilitated, effort to foster awareness, training, and acceptance of business modeling and the FS IM Framework Methodology needs to take place. Training to develop collaborative problem solving skills is also needed.
4. We recommend this work should be undertaken soon and yield the following products within one year:
 - A dictionary of all data elements stored in the IRI databases throughout the hierarchy.
 - A plan to manage change for the 4 levels of the EM business model and for the data dictionary.
 - The IRI database design (structure).
 - An initial operational database for use by field units.
5. We recommend that the FS budget process be aligned with this approach, i.e., it is a inter-disciplinary undertaking which deserves inter-disciplinary funding - possibly by pooling inventory money from all the various agency functions which conduct inventory work.
6. We recommend a strong effort be exerted to involve external government agencies, interest groups, and other parties in the planning for and development of the business model and other products.

CHARTS



Information System Development is a sociotechnical endeavor which will never be perfect. The goal is continual improvement.

B. Identify changes needed for national information requirements for ecosystem management. What are the minimum ecological and resource inventory layers in a national standard GIS that are needed for planning and analysis at multiple geographic scales? What components are integrated in and between layers?

Existing themes are okay with the following comments:

1. Ecology theme needs clarification and expansion. Are ELU and PNV independent or synonymous? Need some standardization on how PNV is derived/defined.
2. Wildlife and fish theme should be expanded to a faunal theme to accommodate all animals (vertebrates, invertebrates).

3. Add themes:

Sub-Surface/Below Ground Processors/Organisms/Functions.

Watershed Boundaries by WRC Code.

Land Disturbance History (Incl. & Beyond MetaData).

Layers That Have No Boundaries.

4. No minimum standard set of analysis processes are needed. Every "unit" will have its own set of data and resources.

5. A standard set of analyses, reports, and maps could and probably should be developed for forest planning because of spatial questions and analysis capabilities. Standardized reports and maps will probably emerge, but unknown reports, maps and analysis exist at this point.

6. Need to look at landscapes and not just economically viable features.

7. Additional teams need to follow-up.
-- national theme teams.

8. Need minimum national standards which allow local flexibility.

Common Themes/Layers to include:

Atmosphere

Geosphere/Hydrosphere

Biosphere

Human Dimension Socio/Ecosphere

Note: These four concepts should be viewed as circular structures which overlap each other.

SOCIO-ECONOMIC

Subsistence

Usual R.M.

Rec. Place/ROS

Demographics >>>> city/town

Labor Statistics >>>> county, state

Geosphere

Geosphere (derived)

Aquatic Unit

Wetlands?

watersheds

hydric soils

channel typed streams

hydrophytic plants

lakes, ponds

seasonal flooding

stream order and class

seasonal flooding or saturation

floodplains

groundwater

Minerals

known reserve
undiscovered
USGS

BIOSPHERE

Veg/Flora

seral stage
harvest units
plot data
physical structure
plant species
plant community
size class
canopy type
condition
spp. diversity

GEOSPHERE

IRI

Terrestrial Unit

soils
elevation DEM
aspect
landform
slope
drainage frequency
surficial geology
subsurface geology
caves

ATMOSPHERIC

Air Quality

Lands

Human Features

Climate

wind
temperature
solar radiation
precipitation
lunar

ownership
jurisdiction
easements
encumbrances
special uses
political/adm. bounds.
(allotment bounds.)

roads
buildings
dams
bridges
utilities
rec. sites
trails
cultural sites
wildlife use & assoc.
mgmt. boundary
fences

Note: The Atmospheric designation connects to all four categories above (air quality, lands, human features, and climate). Moreover, the Air Quality designation connects to the Climate designation.

BIOSPHERE

Natural Disturb. Regime (In each sphere?)

Fauna

Pot. Nat. Veg.

fish pop

fire	wildlife pop
Can these be mapped?	invert pop
Do they need to be?	ichthyological provinces
-- veg	zoogeographic regions
-- soils	microbes
-- climate	diversity
-- F & LJJ	

Methods:

1. Flexible to Adapt to Changes in Needs -- Not Adequate to Meet Current Needs.
2. Modify Inventory to Meet Information Needs.
3. Flora/Fauna Replace Wildlife/Fish/Veg.
4. Redefine Ecology Layer (Or Delete).
5. Constructed Features (Themes) Presented as Consolidated Layer.
6. Need to have standardized layers and cartographic feature files (CFF's) need to be the base layers to which these "other" standard layers are related and registered.
7. Identify minimum layers with flexibility to generate other layers from attributes. Concern over number of layers.
8. Hierarchical scales -- need for expansion for information collected in future.

C. Establish common terminology for ecosystem management. Identify candidate terms for a proposed "National Glossary on Ecosystem Management" Identify reference works, sources of definitions, other relevant glossaries, and proposed definitions that may be used in developing this Glossary.

1. We recognize several reasons for the development of a Forest Service Ecosystem Management Glossary: many terms have a specific meaning in Forest Service usage--if we don't capture those definitions, they may be defined for us in a way that is not compatible; we use terms as a communication tool--clear definitions will help ensure that we are not talking about different concepts or using terms in an ambiguous manner; President Clinton emphasized in his speech at the Forest Conference: "Government will speak with one voice"
2. We recommend the following steps be taken to create the Glossary:
 - a. Identify the main users of the Glossary and who will make the final decision on which terms to include and which definition (in some cases multiple definitions may be warranted) to use.
 - b. First draft should be compiled by representative task force; assemble existing terms and sources into a "stack"; work through stack to get review product; how the FS uses the term should be what glossary contains

- c. Coordinate review with broad range of potential users--all Deputy Areas within FS, other federal and state agencies, OGC, universities, partners, and interested public
- 3. We recommend the following list of terms be considered for inclusion in a national glossary. To increase utility, terms have been grouped into two sets--one set for general ecosystem management use (with perhaps thirty or so key terms) and one set specific to ecological classification, inventory, and mapping standards. Definitions should be developed considering the factors of scale (both temporal and spatial as expressed in hierarchical levels), that each area/forest is dynamic (not just a point in time), and that linkages between systems are important.
 - a. General ecosystem management terms
 - aquatic ecosystem
 - classification/ecological classification (differentiate from "ecosystem")
 - conservation biology
 - corporate database
 - desired future condition (temporal v. a specific point in time)
 - ecosystem
 - ecosystem health
 - ecosystem management (ecological approach to multiple-use management)
 - forest health
 - human dimension
 - inventory
 - landscape ecology
 - mapping
 - mineral resource management
 - natural conditions
 - naturalness
 - range of natural variability
 - riparian ecosystem
 - sustainable ecosystem
 - terrestrial ecosystem
 - wilderness (legal definition)
 - wilderness management
 - b. Terms specific To ECI&M
 - * all terms used in EcoMap hierarchy paper 1/
 - * human dimension classification terms from issue paper 2/
 - accuracy
 - aquatic ecosystem
 - classification
 - community type
 - cover type
 - demands and needs 2/
 - detection
 - disturbance
 - diversity index
 - ecological land unit 1/
 - ecological status
 - ecological type 1/
 - ecotone
 - ecoregion 1/

existing vegetation
 forest type
 habitat type
 hierarchy
 history 2/
 hydrologic unit
 hyporheric zone
 index of biological integrity
 influence zone
 inventory
 land cover classification 1/
 landscape
 mapping
 market area 2/
 mineral potential
 "modeling terms"
 monitoring
 perturbation
 plant association
 population
 potential natural vegetation
 precision
 quality assurance
 quality control
 range site
 resilience
 resolution
 resource character 2/
 riparian ecosystem
 recreation opportunity spectrum
 sample size
 social situation 2/
 "statistical terms"
 stream reach
 succession
 terrestrial ecosystem
 visual quality objective
 watershed

4. We recognize there are alternative ways to structure, format, and issue the glossary. We recommend that it be appropriate to use multiple formats, although two major considerations are keeping it "legal" (perhaps by locating in directives system) and keeping it dynamic (building in a process for change). The following alternatives should receive consideration:

Issue as a General Technical Report, with sections for biological terms, social terms, economic terms
 FSM/FSH
 On-line (Data General/Project 615)
 A brochure with key terms
 Hypertext (computerized cross-reference)
 Model after the Wild Land Planning Glossary
 Perhaps develop subsets for Regional use after all terms and sources have been compiled

5. We recognize that there are many existing definitions to work from. We identified the following list of references that could be used as sources for both terms and their definitions
 - a. WO sources including Biodiversity terms from Bob Szaro workshop in Sacramento, July, 1992; FSH 2090.11 and other directives; Proceedings of Salt Lake City workshop; EcoMap hierarchy paper; Overbay's keynote
 - b. Query Regions/Stations/GSC and compile lists and sources under development
 - c. Other Federal agencies including the Federal Geographic Data Committee, Soil Conservation Service, US Geological Survey
 - d. Natural Resource Societies definitions including Society for Range Management Unity in Concepts Committee, Society of American Foresters terms, Glossary for Soil Scientists, Ecological Society of America, Resource Conservation Glossary, American Society for Photogrammetry and Remote Sensing, Environmental and special interest groups, Renewable Natural Resources Foundation; meeting in Vail, CO, 1992.

D. What is the resource specialist's role in maintaining information and quality standards.

General

1. Don't want resource specialist (RS) to be data management specialist.
2. RS must be computer literate.
3. Central direction needed.
 - need non-functional manual
 - delete existing manual functionalism
 - Resource Inventory Handbook 1900
 - market results.
4. RS must identify data needed by user community.
5. Roles in system - identify participant accountability for resource.
6. Distinguish between conclusions drawn from data analysis and best professional judgement.
7. Accuracy assessment of resources data vs. quality control (collection recording standards).

SYSTEMS- storage, retrieval, definition

1. Specialists are not responsible -- should not have lead -- but should be actively involved.
2. Coordinate with data manager.
3. Ability to compile data upwards (need for data at national level).
 - RS role: I.D. data attributes.
4. Standardize information so all users can understand.

-- RS role: Put data in these useable formats.

5. Awareness of accountability role/needs.

ANALYSIS (Data Sets) & INTERPRETATION - NEPA Component, Information needs of others.

1. Recognize limits of data [risk assessment + what interpretation] is made from data, what is judgement.

-- RS role: Disclosure of credibility confidence level in data.

2. Interpretation of data appropriate?

-- RS role: Needs to concur or disagree with interpretation.
(professional ethics).

INVENTORY COORDINATION INA Internal and External

1. Conduct INA with user groups (I & E).

-- RS role: participate

2. ID other data collectors and potential partners.

-- RS role: identify, network.

3. Facilitate the sharing of information.

-- RS role: attitude, publish data, interpretation & analysis

4. Coordinate/National Biological Survey.

-- RS role: understand, participate

5. Need for data at National level -- Where does it fit in hierarchy?
(Chapter 20 of Resource Inventory Handbook)

-- RS role: identify data attributes

6. Inventory and evaluate our inventory.

-- RS role: participate in review team.

7. Revisit INA's periodically (1 year, 5 year feedback loop whenever necessary).

-- RS role: stay current on issues, bring forward information needs.

DATA STANDARDS -- Use or Create

1. Standard collection method.

-- RS role: agreement on methods

-- RS role: develop standard methodology

-- RS role: follow standard methodology for corporate data base.

- what is optional (shelf life, short term, long term?)

- what is standardized

2. Define and Document data quality.

-- RS role: why it's there

3. Involvement in setting data quality and limits.

-- RS role: active participant

4. Stay current with latest changes.
5. Document protocol for data collection.
 - outline methodology
 - outline techniques used (critical in short-term)
6. Define quality control/accuracy assessment relationship.

DATA COLLECTION - External data, inventory, implementation, quality control.

1. Coordinate with National Biological Survey.
 - RS role: Pro-active participation
2. Data management needs to be integrated.
 - RS role: ID approach
3. Measurement locations need to be documented.
 - RS role: Follow documentation standards
4. Define quality control/accuracy assessment relationship.

MONITORING AND VALIDATION - Quality control

1. ID validation monitoring needs and work with research to accomplish.
 - RS role: Meet with research from time to time to discuss monitoring concerns.
 - forest planning standards & guidelines
 - are we following national standards
2. Inventory and evaluate our inventories.
 - Is it good, useable, merit being kept?
 - RS role: participate on review team
3. Data management needs to be integrated, ID approach to decide on data needs (quality control).
4. Be up front. What data is lacking.
 - RS disclosure: confident level, credibility
5. Revisit INA periodically.
 - RS role: stay current

The objective is to develop proposed strategic approaches to ensure that Forest Service inventories, land classification, and mapping efforts are fully integrated to support the Forest Service's ecological approach to multiple use management.

Integrated inventories have always been considered extremely important to comprehensive planning for public lands under multiple use management. Current NFMA regs, FSM direction, and similar guidance all call for integration in the planning and implementation of resource inventories. If integration was important in the past, it is absolutely essential now under ecosystem management. In fact, integrated inventories are one of six key principles of ecosystem management. In addition, many of the other principles are directly tied to classification, mapping and inventory. Such integration is essential for collaborating between National Forest Systems and Research and coordinating across ownership and jurisdictional boundaries.

While the direction is there and there is general support for the idea of integration, there is also general agreement that it is not working as well as it should. Barriers most often cited in the response to the questionnaire include lack of agreement on inventory objectives, functionalism, lack of communication, and organizational parochialism.

Inventory Objectives Unclear -- Poor understanding of, or lack of consensus on, the priority resource questions to be addressed is a common problem. Such problem identification is essential to establish objectives for inventory, classification, mapping, and monitoring. Without clearly articulated objectives, it is impossible to develop appropriate sampling designs, etc.

Functionalism -- in organizational attitudes, budgets, and processes is the enemy of integration. Yet in spite of lip service to interdisciplinarity, the dogs of functionalism still roam freely upon the land. They become even more vicious in times of budget stress.

Poor Communication/Coordination -- both within an organizational unit, and among and between organizational levels and administrative units, has led to much of the inefficiency and duplication we see today. This is illustrated by the failure of functional people, and EM people as well, to consult other functions about matters that the others may have dealt with for a good many years. Thus, we end up reinventing the wheel by ignoring collective Forest Service experience -- whether it may be "functionally tainted" or not.

Agency Parochialism -- then there is always the "it wasn't invented here syndrome," which is perhaps the biggest barrier we face in the agency. If we didn't develop it, it can't be any good. Hence we won't use it.

The fact that these major barriers have been recognized before makes it clear that successfully eliminating them will be a formidable task. Any strategy must include at least the following:

- o Clear identification of the major resource questions needing to be addressed. This could be arranged by level of the planning process (RPA

questions, Regional or multi-forest issues, forest planning questions, project level questions) and/or along an ecological hierarchy. It is essential that line officers be involved intimately in this process to identify and prioritize the critical questions.

- o Create organizational incentives for interdisciplinary behavior and attitudes. Seek to discourage functional attitudes and approaches. Ecosystem Management provides the framework for this, but is not sufficient in itself. New institutional approaches are needed -- including, perhaps a non-functional EM budget for inventory, survey and monitoring.
- o All disciplines will need to be involved and have an equal voice. Involvement must be conducted in an interdisciplinary fashion. It won't work to have each discipline independently develop their own scheme and then bring the scheme to the table.
- o Depending upon the scale of the question being addressed, we will need cooperative participation of several regions, several Forest, outside interests, universities, other agencies, other governments (States), and other interested parties and cooperators.

Where Are We?

So our task in Phoenix is to extend the work started at the Salt Lake City workshop, on how to plan, organize and budget to implement integrated classifications, mapping, and inventories.

Some changes have occurred in the past year. A WO ecosystem management interdisciplinary team (EMIDT) was formed as a direct result of one of the Salt Lake recommendations. Concurrent with the effort to form EMIDT, the ECOMAP Task Team was formed, to develop a strategy for the timely completion of a coordinated mapping and inventory program.

While progress has been made, much more remains to be done.

In the responses to the questionnaire for this workshop, several themes emerged:

- o We are starting at many different points in the continuum of integrated budget, organization and inventory. This is not bad or even an impediment, but it is a reality.
- o While we share a common vision of an integrated organization, the details vary. Some feel this needs to be reflected in organizational structure (for instance a single inventory organization), while others feel it can occur within the current structures if we learn to communicate and coordinate more effectively. Some proposed the use of teams to manage and implement the programs in a shared leadership context.
- o Sharing of data across ownership lines is becoming increasingly important to all concerned with taking an ecological approach. Data needs to be compatible and in a transportable format. Yet getting agreement on common data definitions and standards has been slow.

- o Some feel that the relationship and integration of FIA units with NFS needs to be strengthened.
- o There were a variety of views on whether and how to amend current budgeting approaches to encourage integration of inventories. Many thought some different approach was needed, although no clear consensus emerged. The suggestions ranged from no change (just better coordination); to functional funding, but for more than just soils and timber, and then integrate the funds into a multi-financed project; to one budget line item for inventory.

The Task Ahead

Our task is to develop the strategies needed to implement the goals of integrated classifications, mapping, and inventories. It should be clear by now that this is a **"WORKING"** workshop!

You will be divided into small groups centered around three topic areas:

1. Recommend a strategic planning process for integrated inventory, classification and mapping, including a timeline for implementation.
2. Identify barriers to integration and suggest how they can best be removed.
3. Recommend organizational and budgetary structures for achieving the needed coordination and integration of inventories, classification and mapping for all levels of the organization.

These are clearly overlapping areas, but it will be helpful if we take different approaches in discussing the topic. In your discussions, include any recommended changes to national policy and direction that you feel pertinent. **Remember, we are looking for reasonable answers and approaches, not just a list of problems.**

Try to make your recommendations as specific as possible. The more concrete the proposal, the more useful it is likely to be. Recommendations should be crafted for the specific type of inventory involved.

For example, we have inventories of ecological land units that include geology, soils, estimates of potential natural vegetation, etc. Such information does not change, and once gathered, is valid for many years. Other inventories encompass existing vegetation that is dynamic and changing and must be periodically reinventoried.

Each of these inventories has specific objectives, and your recommendations for integrating them should be specific to those objectives.

Within an integrated inventory structure, there is a need for map-based inventories to get site specific, in-place information to support project planning. But there is also a role for sample-based inventories to provide resource condition and trends, vegetation growth and mortality, and related data. Proposed strategies should address such roles, as appropriate.

The task teams should also address the appropriate roles and responsibilities in inventory of the four Forest Service organizational levels -- WO, RO, SO, and RD.

After you have had the chance to discuss in small groups, you will be brought together into larger topic groups to develop a single product, which will later be presented to the entire workshop.

I think this is an area where we have had a lot of thought and discussion already; now is the time to pull it together into some hard recommendations. I'm sure you are up to the task!

COMBINED RECOMMENDATIONS: Issue 2 - Strategic Planning, Organization, and Budget.

A. Recommend a strategic planning process for integrated inventory, classification and mapping, including a timeline for completion.

1. Conduct a hierarchical information needs analysis (INA). This should take a view not only of the present, but also include futuring for a changing operating environment. It should identify and fill information data gaps.

The INA should stress integrated, non-redundant data collection to specified national minimum standards. Sampling techniques should be consistent to allow combining and sharing of data.

The INA must be conducted blind to jurisdictional boundaries (see #3 below).

2. Regions and national forests should establish an integrated team to share leadership for ecological classification, mapping and inventory (ECI&M). The teams would decide the most cost efficient means to accomplish the work. The Regional Team leader position should be a full time coordinator position, and that person should be a full and participating member of the ECOMAP Task Team. ECOMAP budget should reflect the need for travel and per diem to allow for this participation. Team members at all levels must be given sufficient relief from existing duties so they can operate as a team and to the needed level of involvement.

3. In all we do, it is imperative to involve not only internal partners such as Forest Inventory and Analysis units, but also other federal agencies, and private partners as well. This involvement must be included in all aspects of ECI&M, including memberships on ECI&M teams at all levels of the Forest Service, the INA, the data collection protocols, the data structure and business models, and procedures for sharing data across ownerships and data systems.

4. The ECOMAP Task Team (including representatives from regional teams and GSC) must define what levels of the Forest Service will accomplish which tasks.

B. Identify barriers to integration and suggest how they can best be removed.

1. The following barriers were among those identified:

- a) Organizational structure, budgets and targets are functional, and hinder integration
- b) Communications
- c) Definitions
- d) Education/professional background skills/awareness
- e) Traditional business
 - lack of linkages between data systems
 - lack of common data bases and approaches
 - lack of a common goals & objectives for scarce inventory dollars
 - lack of a common approach to ecological classification, mapping and inventory, often even within regions

- integration not rewarded
 - non-timber/non-traditional resources often overlooked - imbalance in funding and staffing
 - "data ownership" discourages access, sharing, and cooperation
- f) Time frames
- g) Lack of commitment from line officers at all levels

2. Recommended solutions:

- a) Establish interdisciplinary ECI&M teams at all levels of the organization to guide the process in support of ecosystems management, along with a clear definition of the roles at each level.
- b) Remove "hard targets" for ECI&M that are associated with functional areas. Replace them with targets and direction for integrated ECI&M in one coordinated pool of money. RO/SO requests for dollars and target need to be framed in a coordinated and integrated fashion. In lieu of a single source of funding from Congress, ECI&M dollars should be pooled and multi-funded to the regional from the national office. If possible, provide flexibility in budgets for inventory, such as guaranteed carryover, in order to recognize that not all tasks in ECI&M result in measurable outcomes.
- c) Develop well understood, clearly stated definitions and terms, and use them consistently at all levels.
- d) Share information more freely using the DG and other networks (E-mail); establish a periodic newsletter on ECOMAP activities and decisions. There is a great need to communicate, share and involve partners.
- e) Couple ECI&M with planning (Forest and RPA) and the decision making process. Use planning issues as the basis for inventory. Establish a minimum data set that crosses land ownership boundaries.
- f) Training needs to be a priority, even with reduced budgets. We need to develop cross-functional trust and understanding/awareness, along with an understanding the new technologies and procedures.
- g) Establish regional implementation plans and priorities for ECI&M and set schedules and timelines to facilitate coordinated efforts. These should recognize that the transition period will be less productive until those implementing are trained and adjust to the changes.
- h) Adopt a national business model for ECI&M data management and access.
- i) Pull together into one Handbook, all existing and new direction on ECI&M. This was done for K-V and has worked well towards developing common understanding and consistency.

j) Continue to develop an understanding of the aquatic and human dimension aspects of ECI&M, and where possible, integrate them with the terrestrial.

k) Provide incentives for integrated ECI&M at all levels of the organization. Recognize and reward collaboration and partnerships. Change performance elements for all involved with ECI&M (including all line officers) to evaluate integration, cooperation and accomplishments.

C. Recommend organizational budgetary structures for achieving the needed coordination and integration of inventories, classification, and mapping for all levels of the organization.

VISION - By the year 1998 the Ecosystem Management, Mapping, Inventory and Classification Program will be fully integrated in the F.S. The Program reflects an integrated staffing team approach to accomplish unit needs. Funding is cross-functional with allocations to accomplish unit needs. Ecological classification is in place.

Eco Management is the way we will conduct business and adequate funding is needed to give us the organizational structure to accomplish Ecological Classification and inventory.

Reorganize to promote IRI inter-resource/functional coordination, cooperation and synergy not functionalism. Change titles and some duties of Line officers.

The Role of the W.O is:

- Facilitate consistency.
- Present budget needs to Congress and the Administration.
- Coordinate with other federal agencies (admin.) national direction.
- Provide direction and liaison with other agencies involved in ECM.
- Assure that policy and accountability reinforce complementary recurrent resource inventories.
- Promote and fund R&D of ecological ECI&M.
- Build RPA assessment/program around "EM" and to achieve ECI&M within a 10-20 year time frame.
- Establish "corporate information environment" by 1998 (?).
- Minimize upward reporting that is not essential for accountability to Congress/Administration. Limit to that which is in corporate information.
- Maintain a "corporate mapping reference center at GSC with duties included in its mission statement.

The Role of the R.O. is:

- Inter-forest consistency (QC) and standards. Coordination of complementary inventories.
- Liaison at multi-state level on ECI&M.
- Coordinate within region EM needs relating to inventory and proposed national direction.
- Facilitate consistency in addressing issues that go beyond district/forest boundaries (bio-regional).
- Coordination with other Regions.
- Facilitate movement toward shared service concept among forests where it logically fits from an ecosystem approach.
- May need to establish more "REGIONAL OFFICES" - perhaps by States or portions of States.
- Promote implementation of "corporate information" on forests.

The Role of the S.O. is:

- Maintain the integrated forest-wide data base.
- Budgeting of priorities for Forests, based on Forest-wide leadership team analysis of needs.
- Monitor Forest Plan implementation, ensuring ecosystem approach is being used.
- Provide technical support/quality control for District Based inventory efforts.
- Coordinate IRI team survey programs. Multi-forest IRD inventory (allows sharing of limited resource expertise).

The Role of the R.D. is:

- Generate projects based on ecosystem principles which help implement the Forest Plan.
- Collect and assemble data to be used in the Forest Integrated data base.
- Connect/communicate with local publics
- Connect/communicate with other districts; boundaries.
- Plan and implement coordinated inventories (see S.O. IRI team approach).
- Verify accuracy of classification systems

Organizational Recommendations (none imply new positions, rather re-positioning people with training if nec.)

- 1) Full-time responsibility in ECI&M by a person or team at all levels.
- 2) Full-time responsibility in inv/class. with skill pool if (PT) specialist working for ***** at WO, RO, inter-RO, possibly SO, inter SO.
- 3) Separate advisory people and doers, need close communication but will help get something done.
- 4) Deal with Bio-region levels instead of Forest/administrative units, with multi-funded people.
- 5) Eliminate functional structure at all levels. Examples: A) inv/class, imp., planning, OP, etc. B) Policy/process, vis. exp, veg./terres., T&E, rip/aquatic, protection. C) Admin., EM inv., EM plan, EM imp.
- 6) Form changeable teams across functional boundaries.
- 7) Shared leadership model across functional staff - pool dollars.
- 8) Centralize inventory/mapping (modeled after cartographic features file), include other agencies and organizations.

* Functionalism - need to keep expertise but not try to completely eliminate. Team is made up of functional members but operating in an integrated, cohesive mode towards achieving shared, common goals.

Build organization from bottom up R.D.'s, S.O. then R.O, W.O. - make conversion at all levels.

Mirror image up and down the line may not be the best idea; some inter-SO, inter-RO, inter-Dist. necessary.

9) Responsibilities assigned at inter-agency national level for leadership. i.e. USDA-FS - veg. inventory, SCS - Soil inventory, USFWS - wildlife populations, etc.

Budget Recommendations

- 1) Single-activity code for inventory.
- 2) Streamline budget process to free up time.
- 3) Arbitrary cuts at levels in organization where functional organization prevails to force integration.

ISSUE PAPER 3. UNIFORM PROCESSES FOR ECOLOGICAL CLASSIFICATION AND RESOURCE MAPPING, AND INVENTORIES

The purpose of this session is to define minimum processes for conducting ecological and resource mapping, ecological classification, inventories, and monitoring to ensure integration, consistency, linkage with the human dimension, and comparability across Forest Service units. Work groups will be formed to develop national direction regarding standard processes for data collection, linkages between aquatic classification and inventory with ecological units, and linkages of ecological land units with our other resource inventory and monitoring activities.

Current Status and Direction

If one compares resource data from one Forest Service unit to another, we will find differences in the information available even though the biological, physical and human situations are the same. Information gaps are present and inconsistencies of existing data are evident. These may be partly due to differences in priorities and to the fact that different field units use different techniques and standards to collect the resource information.

To fill other information gaps and to promote more consistency in resource mapping and inventory approaches, the Washington Office, with input from the field, has developed direction in the form of Manuals, Handbooks and more recently memos. Our philosophy to date was to minimize direction to the field. We operated under the assumption that if we outlined our information needs, and provided standards and definitions to meet those needs, then whatever methods the field chose to use was acceptable.

FSH 1909.14 Resource Inventory Handbook and the supporting Interim Resource Inventory Glossary were developed by an interdisciplinary team at the WO following recommendations from the 1984 Integrated Resource Inventory Workshop held in Portland. Chapter 10 of FSH 1909.14 provides general guidance in designing inventories and Chapter 20 is essentially an information needs assessment. Both the handbook and the glossary were sent to the field for review at least 3 times before they were eventually issued.

Since the issuance of the Glossary in 1989 and the latest version of FSH 1909.14 in 1990, the Forest Service has embarked upon ecosystem management.

Current national direction for ecological classification and ecological unit mapping and inventory is in FSM 2060 and FSH 2090.11. Development of this direction was done with major input from the field.

A continued need for more standardization in data collection methodology also emerged as a recommendation from the Proceedings of the National Workshop on **Taking an Ecological Approach to Management** that was held nearly a year ago in Salt Lake City.

Memos have been issued from WO calling for more consistency in data collection techniques and data available. George Leonard's memo of November 15, 1992 requiring western regions to have a network of permanent sample plots on forested lands is one example.

In addition to our own direction, the Forest Service has launched into partnerships with other federal agencies. Our Forest Health Monitoring program, for example, is heavily tied to EPA's Ecological Monitoring and Assessment Program (EMAP). Our ecological unit inventories are tied to the SCS and BLM through the National Cooperative Soil Survey. These linkages require that we also meet the needs of our partner agencies.

Field Response to Questionnaire on Inventory Processes.

Most field units, in response to the questionnaire included in Overbay's memo of February 19, indicated that they are following national direction, but there are apparent differences in applications. Some respondents, for example, indicated a need to revise FSM 2060 and FSH 2090.11 and add a section on the hierarchical framework of ecological units.

Unfortunately, some field units are not able to provide the data called for and some choose not to follow the definitions and standards provided in our direction for a variety of reasons. Most Regions and Stations are collecting some of the information specified in the direction, but no field unit is collecting it all. In addition, in many cases the linkages of our mapping efforts with sampling efforts called for in Leonard's memo and through EMAP are weak.

More recently, of those of you responding to question 4 attached to Overbay's 1360/1330-1 (WSA) memo of January 20, 1993, two regions felt that existing direction was adequate and two stations were neutral. However, an overwhelming seven regions and four stations did not feel that current direction was adequate.

Some of the comments were as follows:

"The direction provided here probably needs additional definition."

"There is confusion over just what an ecological type classification is and how it could be useful (or tailored to be made useful) to many resources."

"The direction is accurate, but does not go far enough."

"...direction for standard inventory procedures must address both terrestrial and aquatic environments."

"...to address the integration of other inventory and resource data, it may need to be expanded to address the integration of other inventory/resource data relating to the ecological unit."

"Direction needs to be more specific. Needs to recognize hierarchy of ecological units."

"The direction in FSM 2060 is appropriate for the terrestrial portion of the ecosystem but is lacking in the aquatic area."

"The direction ... should be clarified."

"Current direction in FSH 2090.11 for developing terrestrial Ecological Types and Ecological Units is good, but incomplete."

"Direction to "Use an ecological type classification . . . etc." is not enough."

"This direction is unclear."

"I do not understand the statement in FSM 2060.3. This statement needs clarification."

"What and how to measure aquatic components is needed."

Obviously, most of you feel that additional direction is needed. We in the WO concur. You also indicated that direction concerning resource inventories should reside in one place within the directives system.

Special Ecological Classification Considerations.

1. The current ecological classification work and the draft Hierarchy of Ecological Units has largely been based on the physical landscape components with some attention to vegetation community distribution. There has been concern expressed from wildlife biologists that this work may have limited value for analysis of animal issues, particularly vertebrates. The intent so far has been to consider the ecological units as the base layer with overlays of existing vegetation condition, wildlife populations and their distribution to provide a more complete picture. The issue is how do we integrate our inventories for sound analysis and what national direction is need to gain consistency?

2. Aquatic Element: The "ecological types" as currently described based primarily on terrestrial considerations do not adequately describe the aquatic element. The aquatic element must describe the physical relationship of flowing and standing water to the terrestrial component, and also the relationship of the biologic element to the water component. There are certain water components that can be used to describe the attributes of terrestrial ecological types, such as, infiltration rates and hydrologic conductivity. These elements, however, are but a minor part of the total water component. In order to adequately consider the aquatic element, it is necessary to also consider the relationship to water as it flows across terrestrial units, and the relationship to water dependent biologic systems.

In order to adequately describe an "ecological unit", it is must be recognized that a geomorphic expression of watershed boundaries is more than just a way to analyze data or as an analysis unit, it is an important part of ecological unit description. Delineations based on watershed boundaries will not only better describe ecosystems that include the aquatic biological component, but will also allow for analysis and prediction of management impacts.

An effort is now underway to describe the elements of an aquatic ecological type, and the classification and data elements needed. Based on this

information, it will be possible to determine the "fit" to the existing terrestrial ecological type.

Work Group Assignments

Your task at this workshop is to develop that direction using the suggestions given in the responses to the questions in Overbay's memo, the information from the earlier work groups, the information provided in the poster displays, and your personal knowledge and experiences.

Specifically, you are asked to:

- a. Specify a nation-wide design and structure for our mapping, inventory, and classification programs to reflect the needs of ecosystem management and that goes beyond existing direction and that will provide continuity across regions and stations. What additional dimensions or elements need to be considered? What is needed for quality control? Propose a process to develop uniform inventories related to ecological, vegetation, aquatic, wildlife, social, economic, and cultural resources. Outline a process for linking these new mapping and inventories with past data collection and existing information and outline a process for linking our data with other federal and state agencies.
- b. Specify how the aquatic classification and inventory can be integrated with the national hierarchical framework.
- c. Define how ecological land units are to be used to link to existing vegetation and other inventories and to information for forest and national planning and reporting. How should permanent plot samples now required for timber management (such as those installed by FIA) be linked to the ecological land units and other inventories. How should our data collection activities be tied to the system of permanent plots that are to be created across all lands through EPA's Ecological Monitoring and Assessment Program (EMAP). What should our direction be on use of ecological land units and permanent plots be for resource monitoring? How does the human dimension fit?

All work groups should draft direction that goes beyond that which already exists and will ensure commonalities in data collection methods. Each group should propose a strategy for consolidating resource inventory direction in a single place in the FSM and a single FSH. Recommend what additions and changes to make to that part of our directives which is now FSH 1909.14 and what further direction is needed to augment what is now FSM 2060 and 2090.11. In particular what is needed in these places to ensure the human dimension is fully integrated in defining and managing ecosystems. At the same time, keeping in step with the decentralized nature of our agency, the direction should encourage creativity and ingenuity. Lastly, specify what actions WO, Regions, Stations, and Forests should take to ensure direction is implemented and followed.

This is your opportunity to shape our resource mapping and inventory program and to determine what information we will have at hand in the future. We look forward to your recommendations.

COMBINED RECOMMENDATIONS: Issue 3 - Uniform processes for ecological classification and resource mapping and inventories:

A. Specify a nation-wide design and structure for our mapping, inventory, and classification programs to reflect the needs of ecosystem management and that goes beyond existing direction and that will provide continuity across regions and stations.

Leadership, Team Work, and Coordination

1. Ensure executive commitment exists with leadership and resources.
2. Establish one organizational unit at WO that deals exclusively with inventory and mapping (centralized) that could support the field needs (i.e. Bureau of Census). This group would provide structure and framework for data gathering and applications, uniformity and coordination.
3. Form steering committee of line officers (all levels, all geo regions, all disciplines - representation of all levels, all geo regions, all disciplines all coop. agencies.
4. Develop regional teams of all resource specialist to integrate with NFS and Research in INA development and objectives. Team structure must include individuals with knowledge/expertise in human issues to promote mutual understanding. Formalize in position description responsibility for team leadership coordination budget and accountability for accomplishments. National Inventory Staff. Focus on communications upwards and downwards and within agencies, universities, and other interests. Need organization chart.
5. There is a need for multi-agency umbrella structure (EMAP may serve now, National Biological Survey in future, Federal Government Data Committee (FGDC) may also provide umbrella)

INA and Data Base

1. Information on stock/flow and condition emphasis must link with RPA/LMP effort. The data/info management system should be linked to the hierarchical structure and focus on the interrelationships of elements of data being collected. The data base should link all data together including non-traditional information such as insects. Insure that data structure can accommodate the linkages/share data bases and the data base should be evolutionary over time.

2. Layers required for "Ecosystem Analysis" include:

Ecological units (FSH 2090.11) - Terrestrial, Aquatic.
Current Veg. Conditions.
Socio-Economic- Cultural

Wildlife population counts should be linked to hierarchy/ data base must accommodate the information, but population counts would not be a layer.

Human elements are very important. Human elements should be a separate layer - should be linked with Hierarchy. Human dimension data needs further definement/definition/awareness before linkages and other work can begin in earnest. Such information may include historical tribal boundaries, cultural info, human effects on the land (mapped), altered states relative to resources, gypsy moth, hazardous waste sites, etc.

Make time a data attribute in all layers.

3. Terminology/language differences are critical blocks to incorporating human dimension and biological data glossary is essential to communication and quality assessment. Role of data dictionary must include where the data are located, how they are available (hypertext). Data dictionary must define the temporal aspects

4. Common analytical tools need to be developed for and at each organizational level. Analytical tools coordination and development and maintenance is accomplished by the classification and inventory group in WO/RO and other levels/agencies/external partners (see issue 2 group c report)

5. Access to data base should be intuitive and user friendly and support from IST to facilitate special needs for data. External linkages begin with hardware and software standards of Project 615 which are fed. govt. wide.

Classification

1. FS should revisit Driscoll Eco. Inve. Classification system 1984-1986. Use as reference - 1986 FS publication.
2. Extend peer review process used for any classification system developed.
3. Adopt the 9 level hierarchical structure for classifying ecological types and mapping ecological units at different levels of resolution -- incorporate into the directives system.

Inventory Design

1. Recognize the need for adaptability of the inventory process to meet future needs - sampling strategy, data base design, application software - other elements.
2. Refocus existing inventories. Re-assess and analyze these to cover resource needs. Recognize future data needs will include spatial, temporally, pattern, linkage, function among data considerations.
3. Design data collection to meet local needs. This will generally serve higher level needs well also.

4. Promote the simultaneous sampling, analysis and inventory of all relevant factors at each tier of the National hierarchy. Consider using National Hierarchy in design and development of inventories.

6. Air resources/sub-surface ecologist - non-traditional resource areas must be linked. However, separate human dimension inventory needs from terrestrial, atmospheric, aquatic, biological (Human values vs. human imprints - infrastructure, use, etc.). Even if sampling schemes differ, links in variable definition and common data elements should be used to promote linkages.

7. Utilize a nested sampling design. This may allow one to meet different needs at different nesting levels. The FIA Plot Grid should be used as starting point for additional forest-level work.

8. If a methodology will be changed, avoid lengthy continuing investment in old methods. Overlap periods (applications of both old and new methodology) can be used to help link old and new data. Overlap periods can be designed as well-defined research projects. Inventory/monitoring continues from there under new methods.

9. All ground sample points should be geo-referenced.

Quality Assurance and Quality Control

1. Quality assurance and control cannot be ad hoc. A formal program needs to be implemented which includes:

QC integrated into the measurement process.

QA info. associated with the data

Data standards (precision, accuracy, units, repeatability, comparability)

Feedback loop into the measurement process (methods improvement).

2. Quality Control is a process, not a set of static standards. Quality Control should be developed from an informed approach rather than standards alone. Apply with appropriate flexibility and continuous improvements.

3. Quality control must include confidence intervals in data (i.e. tree age) to be studied. It should also focus on accessibility, clarity, compatibility, consistency, freedom from bias, updatedness, and verifiability (i.e. GPS or latest location method for all inventories).

4. Methods evaluation/improvement should be continuous. Links with research should be developed and maintained to facilitate this.

5. Quality control must be largely internal to data collection. QC procedures allows workers to suggest improvements. Some external auditing is still important however.

6. We can establish some levels of quality control from data collection through data base management. i.e. Contract inspections correlation/review process.

Direction

1. Consolidate all inventory direction into one FSH. Include the glossaries, George Leonard's memo, FSH 1909.14, 6609.15, etc. 2090.11 etc.) and the institutionalization of the hierarchy itself.
2. Determine the minimum data standards. Review data standards in FSH 6609.15 for compatibility upwards and downwards.

B. Specify how the aquatic classification and inventory can be integrated with the national hierarchical framework.

1. Amend directives system at earliest possible chance to include aquatic definitions. FSM 6609.15 is the latest evolution of the glossary/data dictionary started with the Resource Inventory and GIS definition task groups; does not contain section on aquatics (message is "we don't care about aquatic resource"). WO IS&T should develop criteria for terms; have an aquatic group decide what aquatic terms to include based on the criteria and develop definitions
2. Rewrite FSM 2060 and FSH 2090.11 to include aquatic classification, inventory, and mapping system; FSH 2090.11 shows extreme "soil/veg" bias; national EcoMap team needs aquatic person on it. In developing national direction, consider the following factors and recommendations:
 - a. EcoMap needs to develop an aquatics inventory task force--not an ad hoc group; bring aquatics up to speed and develop maps; funding for task force must be forthcoming
 - b. We need to differentiate between classification and mapping (define processes of classification, inventory, and mapping, and how they relate to each other); mapping is the "proof of the pudding" for classification system.
 - c. Ecological units are aggregated into ecosystems depending on use/needs. If it is EU's which integrate components, then it needs to come out in the national framework. Define if integrated mapping means that all lines are coincident for all components
 - d. Boundaries for EU's should be evaluated for relative precision and factual foundation; those boundaries that are absolute should be based on fact and those that are based on interpretation should be handled differently; note the difficulty of mapping the continuum of an aquatic unit as opposed to mapping a land unit
 - e. Geomorphology is a key link in the interaction and should be a determinant of terrestrial map units
 - f. We need to have a work group confirm ichthyological boundaries and identify ones that are significant to ecoregions and ecosubregions; climate gradients are already covered by terrestrial. Identify relationship of subsection lines to ichthyological boundaries. A Regional IDT could take product and explore aquatic lines v. terrestrial lines, also integrating terrestrial with aquatic and riparian, crossing ownerships. Watershed boundaries establish limits to aquatic organisms. Terrestrial data collection needs to include data that influence aquatic (mass stability, erosion) and vice versa.
 - g. Identify where wetlands fall within the classification: are they to be mapped by terrestrial or aquatics? How can Fish and Wildlife Service best help with this (part of task team, advisory, ?)

- h. GIS software must provide storage systems that are compatible for points, lines and polygons (lines and points should contain same attributes as polygons). Scale (point vs. polygon) should not be limiting; scale dependent information such as riparian character must be captured; at broad scale some features are masked as polygons. Sampling protocol for polygons, lines and points needs to be addressed. Information management people need to be included in all GIS questions
3. Continue to develop an aquatic hierarchy to fit within the national framework based on decisionmaking process (see left side of hierarchy chart) oriented to RPA, supporting the forest plan, and to implementing projects. Use the following guidelines in the development:
 - a. National hierarchical framework should be moved to final form; aquatic should be fully included (not truly integrated to date); terrestrial and aquatic need to come together on hierarchy; need to provide guidance to authors of hierarchy paper
 - b. Hierarchical nesting is an issue; all units at one level will be nested within units at upper levels, but the significant boundaries for aquatic units may not be within existing boundaries of terrestrial ecologic units; aquatic ecological units are a continuum as opposed to discrete land unit.
 - c. Fisheries people need ability to cross levels of the national hierarchical framework and to be able to integrate pieces from different levels
 - d. Publications to reference: Four-level Hierarchy for Organizing Wildland Stream Resource Information (Parrott, Marion, and Perkinson); Classification of Wetlands and Deepwater Habitats of the US (USDI, FWS)
 - e. Aquatic "layer" should be a separate horizontal layer integrated vertically with ecological land unit and human dimension layers; vertical integration will involve a number of layers to address a specific question or set of questions; flexible and iterative process. Suggested hierarchical classification of major aquatic systems:

Highest levels (ecoregion and ecosubregion)--biologically significant drainage systems and ichthyological provinces (polygon features such as aquatic networks, watersheds); see also Omernik's delineation of subecoregions

Lower level hierarchy of watersheds and aquatic systems by type:

riverine	lacustrine	phreatic 1/	estuarine	
---	---	---	---	(assoc)
---	---	---	---	(type)
---	---	---	---	(phase)
---	---	---	---	(site)

1/ suggested that groundwater be incorporated into terrestrial ecological inventory with stratigraphic units (include as an attribute to be mapped)

2/ may have "palustrine" at this level

Scalar integration: at landscape level introduce point/linear features, aquatic features (approx 1"=1 mi)

4. Improve coordination and integration across all resources by taking actions on the following:

- a. To promote EM, need to establish biophysical relationships between organisms and their environments: how is it built (form), how does it work (function), how does it evolve (evolution)
- b. Need to continue work to define how to integrate this effort: how to cross scales, how to do analysis, how to coordinate with the human dimension.
- c. Input from all organizational levels must be addressed and incorporated; we cannot pit organizational levels against each other
- d. People chosen as ID team reps should be able to speak for all, not just for themselves; reduces necessity for reps from every area; back off from our narrow focus, think like others from different disciplines; be aware of other components that effect our area of expertise; listen and integrate; create more of an organizational feel; info should come from most appropriate source (i.e., "experts")
- e. In the design phase of inventory there must be integration of information needs of all disciplines; use consistent methodology, taxonomy; cross training among disciplines
- f. We should be able to meet all customers needs while interpreting taxa, interpreting ecological units, and interpreting watersheds

C. Define how ecological land units are to be used to link to existing vegetation and other inventories and to information for forest and national planning and reporting.

Leadership, Teams and Coordination

1. Establish ECI and EcoMap teams at the Station, Region, NF level to determine resource elements and have consistency between ecological types and units. Coordinate with other agencies and partners.
2. Insure that coordination is done within Regions among all functional inventories. All internal inventories are done within an approved Regional/Station framework collecting data that can be include in the ecol. inventory (using ID teams to accomplish this)

INA and Data Base

1. Complete national level INA for national and large scale issues and reporting. Provide direction to Regions (stations) for regional INAs. Do it - developing consistency. Include single source of information for national level information.
2. Specify the core data requirements needed at all administrative levels (consistently across all regions not just NF).
3. Develop a consistent data base structure at each level. (terminology - process).

4. Relationships between all ecological and planning terms be crossed referenced for understanding.
5. Store appropriate ecological data in an electronic environment i.e. computer data base (easily accessible) for needed users up to the Region Level. RO can send info to WO and others agencies as needed.

Design

1. Combine forest health monitoring and EMAP plots with FIA plots and other extensive point plots on NF lands.
2. Recommend consistency in FIA sampling design for east and west and integrate as much of ecological measurements as possible. i.d. appropriate ELU/Type.
3. Evaluate the establishment of a national system of permanent plots at the landscape level of ECS.
4. Wherever possible, point data should be geo-referenced.
5. Determine and specify each ecological type for each sampling point.
6. Develop focus groups to explore techniques to integrate point and polygon data.
7. Monitoring should be identified in the EU data base. May include effectiveness of monitoring.
8. Where possible, stand boundaries, silvex, data sill subscribe to EU/ECS reference data base. Coincide existing vegetation with ecological units where possible perhaps including cultural feature where possible (PNV and existing veg.).
9. Evaluate the nearest neighbor concept and other including statistical concepts. The focus groups could do this.

Direction

1. Specify in the directives systems that
 - a. Stations, Regions, forests will adopt 4 national levels for aggregation of data but give local (R)/NF flexibility to go with all 9.
 - b. Ecological units are the base layers and we will have overlays of human, physical and biological dimensions to provide a more complete picture.
 - c. Ecological units will be used as the basic unit for analysis and decision making.
2. All ECIM direction needs to be consolidated into one FSM/FSH location. The glossary would also be here. Minimize duplication. Product should be

on line. "Rules based format" should be considered. FSH should have an overview section that is non-technical.

NOTES FROM THE CLASSIFICATION MTG./PHOENIX WORKSHOP

APRIL 14, 1993

STRONG AGREEMENT ON:

Doing away with schism between plant ecologist and soils at all levels...

The need to include SCS as a full partner in this effort, which will facilitate continuity across state boundaries. (WO to take action).

Adopting the national framework for integration and consistency.

Developing some level of standardization for collection of data which brings consistency and integration but allows for innovation and the flexibility to adapt new information, technology, etc.

Providing minimum standards for terminology, mapping, etc.

One staff (WO level) that deals with integration of inventory, etc.

Dollars utilized as a strong emphasis for integration.

Discourage single resource inventory; all inventories should be integrated with equal representation on all teams. Need to emphasize sampling flora, soils and trees at one time.

Utilize review process to emphasize integration through formulation of ECOMAP teams at RO/SO. (note..only 2 regions indicated the formation of a regional ECOMAP). Should function as an ad-hock to the WO ECOMAP team to improve communication, integration, etc.

Supplement for 2090.11 needed to gain consistency and instructions on how to map.

SUGGESTIONS FOR ACTION:

Look at the Canadians approach to ecological mapping and design.

Utilize the Soil Survey dollars to fund ecological classification and inventory projects rather than just soil surveys (NOTE: current directions call for integrated inventories). Group supports an integrated approach which funds ecological classification and inventory. Suggest strong emphasis at the WO level, carried out by RO and SO.

Utilize the MOU w/SCS which allows FS to set survey design (w/in standards).

Driscoll report - what is the status? (Janette promised to investigate and get back to group).

Much discussion over what level of detail for survey...R3 using life zones; R8 & 9 have different approach, etc.

Dave Cleland requested comment from group to be sent back to Pete Avers re: National Framework on Heirarchy paper w/cc to Dave.

Suggestion that Plants/Ecology/Soils be visibly together at the WO level.?

Group felt another meeting/workshop necessary to move this forward.

Volunteers to help include:

Dave Cleland, Clint Williams, Craig Locey, Jim Keys, Jim Jordan, and Sheila Logan volunteered. Target date is February, '94.

Suggestions: include outside participants and all resource areas.

OTHER:

Request for a WO review on how EM dollars were spent...encourage an integrated ecological approach.

PROPOSAL FOR A VEGETATION FOCUS AREA STRATEGY

April 15, 1993

The Vegetation Theme Team (Reuben Weisz, R3 LMP, Recorder)

Purpose

The Forest Service should begin a Vegetation Focus Area Strategy using the methodology adopted by the National Information Management Framework.

Background

At the Integrated Ecological and Resource Inventories Workshop, we were asked to determine national level Ecosystem Management information requirements and a minimum set of Geographic Information System themes, layers, features and attributes needed to support integration of inventories. In order accomplish this, groups reviewed work that had been accomplished to date including the Agency's National Geographic Information Structure, and it's successor, the emerging FSH 6609.15 -- Standards for Data and Data Structures. FSH 6609.15 includes a list of themes, features and attributes. However, this list was developed before the Forest Service developed an Ecological Approach to Multiple Use Management. So our working groups examined the handbook from this new perspective. We developed an ecological view of how to categorize the themes needed for GIS into four spheres, and identified several new themes that should be included in future updates of the handbook. We recommended that in order to refine and "finalize" what features and attributes were associated with each theme, that a national theme team would be need to do the work--for example a national stream theme team would be needed to finalize the attributes needed to describe streams.

Simultaneously, another issue group recommended that the goals of Ecosystem Management and Information Management could only be aligned if the methodology adopted by the National Information Management Framework was used to develop information systems needed to support integrated ecological and resources inventories.

Current Condition

An ad hoc group met to review the current condition of the vegetation theme in the Agency. All Regions, Forests and functions are collecting vegetation data. However, we have no common methods of defining, collecting, storing, retrieving and analyzing the data. The result is that we do not have integrated information that is readily accessible, that is managed at or near the source of the information, that can be shared among our selves and with our publics, and that can be utilized in an Ecological Approach to Multiple Use Management.

We defined the next steps needed to implement the recommendations of the workshop with respect to the vegetation theme. We decided that a national Focus Area Strategy using the standard methodology is needed to develop integrated vegetation information for an Ecological Approach to Multiple Use Management. The Chief should charter a group to develop this strategy.

Desired Condition

The adopted system will be the information basis for managing information about vegetation in the Agency and making Ecosystem Management decisions. It will be designed to:

Collect, store, and allow easy use by all functions of basic measured data.

It will allow us to perform all functions needed for an an Ecological Approach to Multiple Use Management including

managing ecological inventories,
identifying ecological relationships,
defining and evaluating ecosystem composition, structure, functions,
spatial patterns, and relationships,
evaluating ecosystem potential utilization,
inventorying ecosystem perturbations, and
protecting and monitoring ecosystem conditions.

Be integrated

- spatially to defined standards and common coordinate referencing systems,
- within and among administrative units and levels,
- among resources and elements of the natural world, including that which we manage and that which we manage to leave alone, and
- through time
- among technologies

Meet legal requirements and organizational requirements.

Provide reliable answers using quality data with known confidence limits.

Establish a suitable basis for consistent interpretations and modeling (wildlife habitat, visual quality, and timber yield, for example), and evaluating interactions between or among elements of the ecosystem.

Be consistent with national standards and definitions while providing creative flexibility at all levels.

Be cost-effective.

Be transferable to foreseeable technology advancements (Project 615).

Meet the needs of users, including internal and external publics.

Build on existing systems in order to take advantage of existing investments in data.

Be fed and maintained as a part of the regular way of doing business in the Agency.

Deliverables

The key deliverables coming out of the Vegetation Focus Area Strategy will be

- o A description of what we need to know about vegetation to do an Ecological Approach to Multiple Use Management. This includes a blueprint (Entity-Relationship Model) of those things that we need to know about vegetation.
- o Definitions of new entities and attributes to needed to update the Data Dictionary contained in FSH 6609.15 -- Standards for Data and Data Structures.
- o A detailed action plan for the Analysis Stage of the methodology that will be used by those who develop the national integrated vegetation information system.

Reasons for Implementing this Proposal Now

1. We want to capitalize on the recommendations coming out of the Integrated Ecological and Resource Inventories Workshop, and the resources that are available to do a national level strategy.
2. Vegetation manipulation is at the core of our on-the-ground management; it is at the core of ecosystem management.
3. Aside from data about people and funds, perhaps no other data is more shared among functions within the Agency, among administrative units within the Agency, and between ourselves and the people that we serve.
4. Major dollars are being invested in the collection of vegetation information. There is a high risk that this money will not be effectively spent until the vegetation information needs are well understood and managed.
5. This project involves virtually all the resource disciplines so that it is ideal for spreading the learning of how to go about information management in a corporate way.
6. Other efforts have indicated that this is an "area of focus". Examples include Region 2 and Region 6's Integrated Resource Inventories and related data base development efforts, Region 6's Vegetation Proposal, this week's agreement among the Deputy Regional Foresters of Regions 1, 2, 3, and 4 for inter-regional cooperation in the development of integrated data for ecosystem management and their interest in promoting this idea nationally.
7. Tim Young's paper on the need for an organization to model its principle entities before embarking on major information system development opportunities. Vegetation is one of the principle entities in the Forest Service.
8. This increases the opportunity to show a big payoff to the Agency's standard methodology in a short period of time. We are in a position to reach agreement rapidly on this principle entity.
9. If we can develop one integrated vegetation information system prior to the arrival of 615, we can substantially reduce the cost of migrating to 615. It

is cheaper to integrate and then migrate, than to have each Region migrate and then integrate.

10. Vegetation information is at the center of much of our Agency's controversy, appeals, and lawsuits. We need credible, consistent, comprehensible and correct vegetation data.

Reasons to Not Adopt This Proposal Now

1. "Vegetation" may not be the right size for a study. It could be too big a subject area or too small a study area. For example, why should we do flora only? Why not develop a strategy for flora and fauna, or for ecosystem management?

2. It's not the right time to do the study. We should wait a couple of years until the results of the Agency-Wide Strategy Study, and other Focus Area Strategies (such as an Ecosystem Management Focus Area Strategy) have been completed.

Critical Success Factors

- o Committed involvement of WO and RO Staff Directors, and line officers at all levels of the organization.
- o Participation of all functions that use vegetation information in our organization.
- o Short time frame (less than 3 months to complete Strategy Stage).

INTEGRATED RESOURCE INVENTORY

Terry Brock, Regional Soil Scientist, Alaska Region.

Ecological Unit Inventory (EUI) is a human derived scheme designed to separate the natural continuum, at various hierarchical levels, into relatively homogeneous units to answer important needs for information. This poster is an example of a product that is currently being used in the Alaska Region. The Chatham Area of the Tongass National Forest in southeast Alaska provides that example. Their approach to EUI was to identify these needs and to develop the inventory scheme based to meet those needs.

The Chatham Area EUI is based on geologic, landform, soil resource, water resource, aquatic resource and potential vegetation (plant association) and stand level (seral stage) data. This information is organized in a geographical information system (GIS) format that can be used by planners and land managers to locate, compare and select suitable areas for major kinds of land use activities; to identify areas that need more intensive investigation; to evaluate various management alternatives and to predict the effects of a given alternative on resource health.

The inventory included coordination of concepts and classification of units that were recognized consistently throughout their distribution. This was accomplished by involving several key disciplines in the identification of criteria and their class limits that are systematic and repeatable in the mapping legend and criteria. Interdisciplinary coordination in the development of critical criteria and class limits insures that the land classification scheme provides adequate resource information for key disciplines. If individual resource needs can be identified and build into the classification system, the result is an integration of multi-disciplinary resource needs, a truly Integrated Resource Inventory.

The level of intensity for a Resource Inventory is defined as medium (order III). This level is highly useful and generally the most cost effective for data collection because of the complicated logistical aspects of inventory in the Alaska Region. The use of helicopters, fixed wing float-planes, boats and walking on very steep rugged terrain are common in the inventory process. It is designed for comprehensive project planning and with aggregation, can be used for broader Land Management Plans. At the project level, it enables the specialist to concentrate on-the-ground efforts to those units most critical for any particular management activity.

A new Regional Integrated Resource Inventory (IRI) for the Alaska Region is under development and has just completed the strategy stage. The IRI will probably include the Terrestrial Ecologic Unit tailored after the Chatham Areas EUI, the Aquatic Ecologic Unit that is currently being developed, and the Existing Vegetation Unit which will reflect the present vegetation condition and include stand level data. The major focus of the IRI throughout the Region will be to use data that presently exists where it is reliable and complete. In places that require additional data collection and inventory, that will be completed where practicable.

U.S. ARMY LAND CONDITION-TREND ANALYSIS PROGRAM:
A MULTI-RESOURCE INVENTORY AND MONITORING SYSTEM

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Abstract. The U.S. Army Land Condition-Trend Analysis (LCTA) Program was developed, beginning in 1984, to meet long-term military objectives in the areas of environmental compliance and land management. The method incorporates inventories of all vascular plants and various faunal classes, as well as a monitoring system based upon permanent plots. Plot data contain information on erosion and other disturbance characteristics, vegetation cover, woody plant density, and soil/topographic features.

Introduction

The Department of Defense (DOD) is responsible for administering more than 25 million acres of federally owned land in the United States (Public Land Law Review Commission 1970), making it the fifth largest Federal land managing agency. In addition, DOD military branches have agreements with states and other Federal land-managing agencies, including the Forest Service, to allow training use of 15 million added acres (Council on Environmental Quality 1989).

Even this land, according to DOD planners, is insufficient to meet demands for larger training areas. Advancing technology is providing weapons systems, along with accompanying tactics, that have increasing requirements for space on the battlefield. Obvious examples are included in the new generation of laser-, thermal-, and optically-guided "smart" warheads. This has led to greater dispersion of ground combat elements. The land area needed to train an infantry or armored battalion has increased about tenfold since World War II (U.S. Dept. of the Army 1978).

Along with increased space requirements for small-unit training, the military is asking for larger training sites to enable integrated air-land training by brigade- and division-sized units (Rozman 1991). The advantage of such training was shown in 1991 by the allied successes during "Operation Desert Storm;" field commanders attributed their quick victories, in part, to division-level training at the 640,000-acre National Training Center at Fort Irwin, CA (Vuono 1991).

Concomitant with the need for larger training areas, DOD is engaged in a program of base downsizing. The report of the DOD Secretary's Commission on Base Realignment and Closures initiated this process in 1988, and it continues under the reduced military budgets in the 1990's. Such an apparent paradoxical approach to land ownership can result in public confusion over the direction of official policy, especially when new lands are sought.

Military commanders responsible for DOD lands must address two important national goals; i.e., maintaining proficient military forces and safeguarding the environment. They became important during the post-Vietnam era when a general deterioration of soil erosion and other environmental conditions became apparent within the U.S. Army to the point where it was starting to degrade training capabilities (Goran et al. 1983). In 1984, the Army convened a panel to evaluate conservation and natural resource management programs, and to recommend improvements (Jahn et al. 1984). The level of influence for environmental stewardship was increased in 1989 when Secretary Cheney stated a policy of having "every command .. be an environmental standard by which other Federal agencies are judged."

Active natural resource management efforts, then, became increasingly necessary for three important reasons; (1) the desire to be good managers of natural resources on military lands, (2) the need to maintain capabilities to continue training on these lands, and (3) to provide mechanisms for helping decide which bases should be closed and where additional land procurements might be most beneficially made under base expansion.

The Land Condition-Trend Analysis Program

As a result of recommendations from the Jahn et al. (1984) report, the U.S. Army Construction Engineering Research Laboratory (CERL) was tasked to devise a natural resources inventory and monitoring program, which came to be called Land Condition-Trend Analysis (LCTA). The LCTA Program was one of several tools designed for protecting and managing natural resources at military training areas. The umbrella program for these tools is called ITAM (Integrated Training Area Management), and it now includes five elements in addition to LCTA; troop education, vegetation rehabilitation/restoration, erosion control, computerized decision support systems, and matching training missions to natural resource requirements (Anderson et al. 1989). LCTA, however, forms the "foundation" of the other five elements because it provides essential information to their operation.

The LCTA Program was developed under principles of sustainable ecosystems and multiple-use management (Turner 1988). It specified standardized methods for data collection, analysis and reporting in order to allow comparisons among different installations, as well as the ability to compile data sets on an Army-wide basis (Diersing et al. 1992).

In devising the LCTA Program, CERL was guided by the following objectives. It must; (1) evaluate the capability of land to meet multiple-use demands of the Army on a sustained basis, (2) monitor and be able to evaluate changes in biotic and abiotic resources, (3) accurately describe conditions and regulations constraining the use of military land, (4) serve as a basis for amending land management plans, (5) ensure standardized data collection, analysis and reporting procedures, and (6) describe completely the flora and fauna on Army installations (Diersing et al. 1992).

The LCTA Program was presented at a workshop at Fort Hood, TX in 1987. Army-wide implementation was recommended shortly thereafter. Since its initial development, the program has expanded to address problems associated with endangered species and wetlands. The extension has been primarily driven by environmental compliance provisions in the National Environmental Policy Act of

1969, the Endangered Species Act of 1973 and the Clean Water Amendments of 1972.

By FY-92, the LCTA Program had been put into effect on more than 50 Army, Air Force and National Guard installations. It is comprised of three components; a floristic survey, a permanent plot-based inventory, and a faunal survey.

Vascular Plant Survey

A complete vascular floristic survey is a key element and the first step in the LCTA process. The survey's objective is to provide a comprehensive botanical list (based upon voucher specimens) for the military installation, to supply reference material for field and herbarium use, and to document the extent and distribution of endangered, threatened or candidate plant species.

The plant survey is conducted during the growing season(s) over several years. Specimens are collected when in flower or fruit (or both) to make certain of positive identification. A standardized plant collection log is used to record country, state, installation county, specific location (UTM coordinates), elevation, date, substrate, topography, associated species, root structure, corolla color, height and relative abundance. Other information may also be documented.

During the preparation of herbarium mounts, at least two specimens are laminated in plastic for field use; one is furnished to the installations's natural resource office and the other to the LCTA implementation crew.

Plot-Based Inventory

LCTA plot inventory data, as well as the faunal survey (to be described below), are obtained from a series of permanent transects. Each military training area has up to 200 of these transects, called core plots, situated across its landscape. Their actual placement is provided by a random procedure that is stratified by land-cover categories. It is the land-cover categories that form the land classification system for the training area.

The land-cover categories are determined from digitized data stored in a GIS. The military uses a GIS called Geographical Resources Analysis Support System (GRASS) (Westervelt 1988). The GIS utilizes two layers to create a cross product map layer, from which the land-cover categories are derived. The layers are (1) a supervised classification, based upon a two-pass clustering algorithm, of satellite reflectance imagery in the green, red, and near-IR bands; and (2) a digital soil survey. CERL uses the French SPOT satellite imagery, but LANDSAT imagery may also be used. The reflectance classification procedure limits the clusters to a maximum of 20 groups (Warren et al. 1990).

LCTA core plots are allocated to polygons in the GRASS cross product map layer on the basis of an iterative, step-wise process that assigns plots to the category with the largest area. Thus, the core plots are stratified on the basis of land-cover area (Warren et al. 1990). Their actual placement within the polygons is from a random point.

The foundation for each core plot is a 100-m transect. A GPS unit is employed to mark its precise random starting point. A transect is then established from

the point in a restricted random (it cannot extend outside of the polygon) direction and marked with five buried 6-mm steel pins to aid exact relocation. The steel pins are placed at 0, 25, 50, 75, and 100 m along the transect, and are secured by installing them inside 1/2-in. pipes that are first hammered into the ground. A complete description of transect establishment is contained in Tazik et al. (1992).

The vegetation inventory is designed to determine dominance on the basis of both ground and canopy cover. The point method (Levy and Madden 1933) was selected because it is rapid and easy to learn (Mueller-Dombois and Ellenberg 1974). One hundred points are read, at 1-m intervals, along the transect by lowering a 1-m metal pin vertically to ground level. Ground cover categories are; basal cover by plant species, prostrate cover by species, litter by life-form, duff (litter > 2.5 cm in depth) by life-form, dead wood (dead plant material > 2.5 cm in at least two dimensions), rock (> 7.5 cm in diameter), gravel (< 7.5 cm in diameter), and bare soil.

At the same time that a point is read, any evidence of physical disturbance by military activity on that point is also recorded. Disturbance categories are; none, pass (vehicle track following no established traffic pattern), trail, road, and other non-vehicular. CERL differentiates between trails and roads by whether they receive maintenance.

Canopy cover of vegetation is estimated at each of 10-cm intervals from the ground to 2 m, and at 50-cm intervals to 8.5 m. A telescoping range pole is used to determine where "hits" occur above 1 m.

Succulent, shrubby and woody plant densities are assessed by registering the number of individuals within a 100 by 6-m belt macroplot superimposed upon the permanent 100-m transect. The belt is formed by extending a telescoping range pole 3 m on each side of the tape delineating the transect. The belt width and minimum height requirement for inclusion can be adjusted for dense vegetation; however, these parameters must remain constant once they are fixed for a given transect.

Qualitative estimates of land use and degree of accelerated erosion are made at each core plot. The observations are based upon conditions within the belt plot. Conditions noted are:

Condition	Categories
1. Military land use	None, wheeled, tracked, excavation, foot, bivouac, demolition, other.
2. Non-military use	None, sheep grazing, cattle grazing, hayland, cropland, managed forest, other.
3. Maintenance activities	None, burning, mowing, tillage, seeding, tree planting, chemical application.
4. Wind erosion	None, drifting, scouring, plant pedestals.
5. Water erosion	None, sheet/rill, active gully, debris dams, plant pedestals.

Finally, supplemental plot information is recorded at each permanent core plot. Items in this category include a rough estimate of soil depth (distance the 5

steel pins marking the transect marking the transect can be driven into the ground) and the soil profile down to 40 cm. Soil samples are also taken for analysis for textural class, Ph and organic carbon.

Faunal Survey

Animal surveys are established on about one-third of an installation's core plots. The plots are selected in a stratified random manner to ensure that major land-cover categories are adequately represented. If important endangered, threatened, or candidate animal species are known to occupy unique habitats, special monitoring procedures are devised for them.

Faunal data are collected on or near the LCTA plots. Only small mammal and song bird data are required as a standard. These taxa are judged as being useful "bioindicators" of ecosystem stability (Douglass 1989, Temple and Wiens 1989). Other faunal data that may be compiled include medium-sized mammals, carnivores, amphibians, reptiles, and invertebrates. In addition, ungulate pellet group counts and browse utilization can be monitored.

Birds are censused using a modified point-count transect technique (Blondel et al. 1981). The observer slowly walks the length of the LCTA transect in 6 minutes, recording all birds seen or heard within 100 m of the transect. Upon reaching the end, the observer stops for 8 minutes and records all birds seen or heard within 100 m. Finally, the observer slowly returns to the starting point, again recording all birds seen or heard within 100 m. The censuses are made in morning and evening hours. If four to five transects can be censused each day, about 60 transects can be monitored during the seasonal peak in breeding bird activity of mid-April to July (Tazik et al. 1992).

Small mammals are surveyed by placing two rows of 20 museum special traps and five rat traps on either side and parallel to the long-axes of selected LCTA transects. The trap lines are placed 30 m apart, and the traps are spaced every 7.5 m. Baiting takes place in the evening, and the traps are checked early the next morning, then reset and rechecked the following day. Setting and monitoring these traps is labor-intensive; therefore, like that for birds, only 60 transects can be sampled.

Medium-sized mammals can be monitored at selected transects using baited cage traps. Animals caught in these traps are routinely released after being recorded. Carnivores are usually not monitored; however, when needed, data can be obtained through the use of scent stations. Scent stations are a 1-m diameter circle of finely sifted sand with a fatty acid scent disk (or other scent) in the center. Carnivores are identified by tracks left in the circle.

Reptiles and amphibians are monitored on selected transects with a pitfall trapping array. The central bucket of each array is located 75 m from the transect's origin at a random azimuth within a 180-degree arc away from the transect. Details about the pitfall trapping array are described in Tazik et al. (1992).

Monitoring

To detect changes in land use, disturbance, ground cover and canopy cover, the permanent core LCTA transects, as well as their attendant plots and traps, are

usually monitored on an annual basis. This relatively high-frequency monitoring, called "short-term" in LCTA manuals, is normally a scaled-down version of the initial inventory. Depending upon the nature and intensity of land use, the core plots are completely resurveyed every 3 to 5 years. The latter is called "long-term monitoring." Short-term monitoring does not include collection of density data from the belt transects.

Uses of LCTA data

LCTA methods were originally designed, in part, to obtain information needed to calculate soil erosion potential based upon the Universal Soil Loss Equation (USLE) (Wischmeier and Smith 1978). Unfortunately, the USLE is not deemed to be suitable to non-agricultural lands according to some researchers, and its usefulness has been the subject of considerable scientific contention (Renard 1984). Additional research must be conducted before the usefulness of LCTA data in predicting soil erosion potential will be known.

One use of the LCTA program has been to estimate the "carrying capacity" of training lands for specific military uses. For example, Shaw and Diersing (1989) predicted allowable use levels for tracked vehicles on the Pinon Canyon Maneuver Site in southeastern Colorado. Such information, of course, is useful during considerations for base closures and land acquisition.

A third explored application of LCTA data is the description and delineation of wildlife habitats (Tazik et al. 1989) and the habitat of threatened and endangered plant species (Schulz and Shaw 1992).

The Rocky Mountain Forest and Range Experiment Station, together with the Center for Ecological Management of Military Lands (CEMML) at Colorado State University, Fort Collins, and CERL, is carrying on an active cooperative research program on present and future uses of LCTA data under the purview of an agreement with CEMML. Application to Forest Service responsibilities can be found in Forest Inventory and Analysis, forest and rangeland ecosystem management, and land management planning.

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THE ROLE OF REMOTE SENSING IN ECOLOGICAL MAPPING.

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Abstract

Remote sensing data provides spatial information on the location, type and condition of forest resources; it has proven as an important source for deriving vegetation layer for forest-wide and other GIS databases. This poster provides an overview of how the various forms of remote sensing are applied at the different levels of ecosystem planning.

The four major levels defined in the "National Hierarchical Framework of Ecological Units" are addressed: a. Ecoregion, b. Sub-ecoregions, c. Landscapes, and d. Land Units. The use of remote sensing and GIS at these levels requires different forms of remote sensing and different analysis techniques.

The poster shows examples from a development project being conducted by the Integration of Remote Sensing program and the Bridger Teton National Forest Integrated Resource Inventory group, under the sponsorship of the Remote Sensing Steering Committee. The sources of data that we used include: weather satellite Advanced Very High Resolution Radiometer (AVHRR), Landsat Thematic Mapper (TM), color infrared aerial photography, digital elevation data (slope, aspect and relief), and ground information (soils, vegetation, etc).

CONTRIBUTIONS OF GIS TO ECOSYSTEMS MANAGEMENT: AN OVERVIEW

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Abstract

Ecosystems are by their nature geographical entities. The unique combination of influences that sustains the interactions of an ecosystem is a product of landform, climate, and the resulting vegetation and fauna. There is an inherent hierarchy of factors well articulated by Bailey (1976) in his maps of the Ecoregions of the United States. Managing geographic data is now most efficiently done in a GIS. This paper takes the boundaries of the states and Regions, National Forests, Bailey's ecoregions and the formal boundaries of the states and considers each in relation to the other and all in relation to the apparent boundaries visible in vegetation greenness (AVHRR-NDVI) nation-wide in March, June, and October 1991.

Introduction

The realization that boundaries around areas of the earth are not necessarily multi-functional has been established for many years. Comparison of boundaries with different functions results in a confusion of purpose. Computer technology has made it increasingly easy to tabulate and process data. Statistical analysis of each data set can give results that are important for managers in decision making. Often it is necessary to establish that data sets are drawn from and apply to the same area, otherwise the conclusions are invalid. This paper reveals how GIS can illustrate the interaction of boundaries at the national and regional level for management purposes.

GIS Structure

The concept of ecosystems management implies that ecoregions and Forest Service regions must be considered together. The regions within a single ecosystem and the ecosystems within a single region must be known and the appropriate ecological and management information must be available. Storing this information in a structured, georeferenced form is the role of the GIS. In this brief study the data entered were drawn from a combination of published sources and on-going programs of work.

A GIS was set up to include a digitized outline of the US with state and county boundaries. This was taken from the published data set ArcUSA. The flexibility of this data set, when used with ArcView or ARC/INFO software includes the ability to change scale, change projection, and create sub-sets of the data for regions of interest. Also from the ArcUSA data set, boundaries of National Forests and Grasslands were added.

Digital data files showing Forest Service Regions were added from data sets available in Forest Service Intermountain Region (Region 4). Digitized maps of Bailey's ecoregions were available from the US Fish and Wildlife Service Gap Analysis Program. All these boundary files were registered together and projected using a Lambert Azimuthal Equal Area Projection.

Map Combinations

For clarity of each of the presentations of the Bailey ecoregion map was made separately. The Domains - three major groups that have expression in the lower 48 states of the USA - are also presented separately. These constitute the formal expression of boundaries established on an ecological basis. (Maps to the left of this text.)

Maps of Forest Service Regions are less clearly presented by the map below showing the distribution of National Forests across the 48 states with state boundaries and Bailey's ecoregions.

There are some obvious correlations between the forest boundaries and Bailey's ecoregions structure. This is to be expected as forest ecoregions can reasonably be expected to contain forest. Equally logical is the presence of National Forests within forest areas, and hence within forested ecoregions.

To make this pertinent to management, Forest Service Region 4 has been enlarged and the Bailey ecoregion section boundaries are shown together with the boundaries of National Forests. The Regional boundary and state boundaries are shown. There is some immediate correlation between the Bailey ecoregion boundaries of the Douglas-fir Wasatch-Uinta section of the Rocky Mountains Forest Province and the Wasatch-Cache, the Ashley, and Uinta National Forests.

NOAA-NDVI Apparent Greenness

The formal boundaries discussed above are essentially the fixed boundaries usually associated with geographical study. It is immediately obvious that Forest Service regions and state boundaries do not necessarily coincide. For management purposes, deviation from a simple aggregation of states has been recognized as a necessity for many years.

The Forest Service boundaries include the forest units of similar type so there is an inherent logic to the structure. This has to be modified in individual cases to provide the complete coverage necessary in a management structure. However, there is an apparent correlation with the major ecoregion structure.

Forest lands also exist in a spatial-temporal domain. Deciduous forests have a leaf-on, leaf-off cycle each year. Evergreens hold their foliage while surrounding vegetation activity ceases or becomes dominant. the use of data from the NOAA polar orbiting weather satellites can provide an index of apparent vegetation greenness. this is achieved by using a ratio of the reflected visible light and the reflected near infra-red energy in an equation which uses the difference between the two over their sum. This ratio is know as the Normalized Difference Vegetation Index (NDVI).

$$\text{NDVI} = \frac{\text{Channel 2} - \text{Channel 1}}{\text{Channel 2} + \text{Channel 1}}$$

Where channel 2 is the Near Infra-red reflective and channel 1 is visible light as gathered by the sensors on the NOAA spacecraft.

By plotting these data in a map format and replacing data for cloud cover areas with data from cloud-free days in a 10-day or 14-day time window, maps of

apparent greenness can be created. Using the data sets of NDVI for 1991 issued by the US Geological Survey EROS Data Center, maps of the lower 48 states were created for March, June and October.

These maps can be compared with the Bailey region boundaries and the result is a combination of boundaries that coincide in areas of forest cover. Coniferous forests tend to have a continuous greenness. these contrast with adjacent areas of alpine meadow, bare rock, salt bush, sage brush or other non-forest vegetation. the same definition only holds true for deciduous forests during their growing season.

Consequently the boundaries of the greenness regions shown in the March 1991, June 1991 and October 1991 maps of NDVI values, reveal the expression of vegetation types at different seasons. These match, to a greater or lesser extent, boundaries of Bailey's ecoregions depending upon the coincidence of present vegetation cover in relation to land use. Bailey's map is not a land use or land use/land cover map and thus the NDVI reflects present conditions rather than ecosystem functions.

Discussion

The seasonal maps of NDVI compared to Bailey's ecoregion boundaries (maps to the right of this text) show interesting correlations at each of the seasons. Detailed analysis of this would be of interest. However, for ecosystems management purposes this is simply a broad overview.

For active management purposes more is to be gained by integrating work using NDVI values in the Forest Service Region and for individual National Forests. this is shown below for Region 4. Bailey's ecoregion boundaries, National Forest boundaries and state lines are shown over the NDVI data for June 1991.

In this composite plot the coincidence of vegetation activity with ecosystem boundaries can be inferred. More detail can be obtained by considering changes throughout the growing season (Ramsey and Falconer in preparation). Management decisions based on ecological principles can be supported by the combination of the rational structuring of ecoregions following the Bailey system and the monitoring of vegetation dynamics using NDVI.

Conclusion

Management by ecosystem principles requires an overall understanding of the inter-relationships between the formal and static boundaries of states, National Forests and Forest Service regions and the dynamic of vegetation as revealed by NDVI maps. However it is clearly not rational to attempt to manage land on the basis of NDVI values as the year-to-year variation is large and seasonal change and fluctuation within seasons is also spatially "unstable".

It is at this level that the Bailey system provides a rational, stable approach to summarizing ecosystem behavior into a coherent regional picture. This coherent overview provides the basis for a rational approach to understanding NDVI fluctuation and the seasonal dynamics of vegetation, and allow us to relate it to the stable formal management boundaries of state lines and regional boundaries. Managing these boundaries and relating them to the fluid

NDVI "boundaries" is an efficient method of presenting these complex interactions to managers.

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A GIS ECOSYSTEM MODEL

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Ecosystem Management is not new, however the computer simulation of ecosystems processes is in its infancy. GIS systems linked with affordable computers capable of quickly processing and storing large data sets bring the reality of ecosystem simulation into focus. Thus, the human mind and its ability to apply reasonable thought, interpret, and understanding ecosystems processes is becoming the limiting factor..

This paper introduces an understandable GIS modeling process that represents in a simplistic sense a functioning ecosystem. The model provides a forum for focusing the discussion on the topic of simulating spatiotemporal ecosystem processes and directing our efforts at defining a tool for implementing ecosystem management across a variety of hierarchical resource classifications strategies.

To quote Jack Ward Thomas "Ecosystems are more complex than we thought, and ecosystems are more complex than we can think".

To model an ecosystem one must first define the ecosystem. From its Greek derivative "Oikos" or study of households, we can define such a model. The next question is "whose household?" Assuming every organism has a life and home, then one must next consider the inter and intra relationships between neighboring organisms. If adjacent neighbors are the same species, the relationship is obviously different than if the neighborhood is composed of different species and life forms. If so, then one must evaluate competition among individuals for ecosystem resources. Is the competition with a "niche", or a neighborhood or the relationship on of symbiotic cooperator, a parasite, or predator?

Barry Commoners rules of ecology humorously show this delusion:

1. Everything is connected to every thing else.

2. Everything must go somewhere.

3. There is no free lunch.

What is an ecosystem? Ecologists define ecosystems with the following interrelated components:

- Composition - the kinds and amounts of biological and physical elements.
- Structure - the vertical and horizontal arrangement of environmental elements
- Pattern - the spatiotemporal arrangement of patches
- Function - the linkages between energy flows, species, and materials.

Thus, we will integrate these components into our ecosystem model!

NOW, HOW DO WE START AND WHAT IS THE ROLE OF GIS IN ECOSYSTEM SIMULATION?

GIS is an automated tool capable of holding maps in digital form and then relating data base attributes or descriptions to map features. In general terms, by using several "snap shots" of time we can simulate ecosystem processes. Once this baseline relationships are understood and represents the ecosystem processes in terms of composition, structure, pattern, and function and we can evaluate management scenarios by using a GIS system to analysis the resulting conditions.

STEP 1 - DEFINE A HIERARCHICAL PROCESS THAT STRATIFIES AND DEFINES THE LAND UNIT BASE OF THE ECOSYSTEM MODEL (something we can get our arms around).

The land unit boundaries can be entered into the GIS and the GIS is used to display broad scale satellite data over several physiographic divisions to verify or redefine landscapes from shaded relief digital elevation data. In defining this hierarchy, it is important to document the functionality rules which associated with each level.

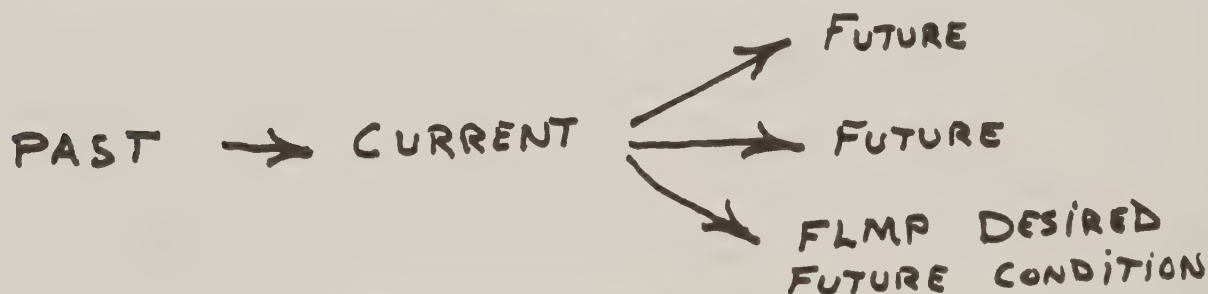
<u>Hierarchy</u>	<u>Unit Name</u>	<u>Functionality</u>
SUB_REGION	Southern Rocky Mountains	(Defines specific ecological processes and functional relationships)
DIVISION	Uinta Mountains	(Defines ecological processes and functional relationships that differ from Wasatch Mountains, etc.)

PROVIDENCE	North Slope	(Separates slopes)
LANDSCAPE	So.Fk. Bear River	(Basic model area represented by processes and functions unique to ground specific slope, aspect, elevation, micro-climates, etc.

KEEP IN MIND THAT LANDSCAPES ARE COMPOSED OF NUMEROUS INDIVIDUAL ECOSYSTEMS COMPRISED OF AN ARRAY OF PLANT COMMUNITIES, ORGANISMS, AND THEIR RESPECTIVE POPULATIONS DOWN TO THE CELL LEVEL!!!

STEP 2 - USING GIS, MODEL THE LANDSCAPE AREA THROUGH TIME. START WITH THE CURRENT SITUATION. NEXT WE WILL GO BACK PRIOR TO ANGLO-MAN'S INFLUENCES (150 YEARS) AND REPEAT THE MODEL. THE NEXT RUN WILL EVALUATE CONDITIONS 150 YEARS IN THE FUTURE. THUS OUR MODEL WILL DEFINE THE MOVEMENTS, FLOWS OF ENERGY BETWEEN ORGANISMS, AND THE CONSEQUENCES OF LONG TERM LANDSCAPE INTERACTIONS (we should be able to portray current and future conditions). IT IS IMPORTANT TO RECOGNIZE THE CHANGES DUE TO MAN'S INFLUENCE, SUCH AS FIRE SUPPRESSION.

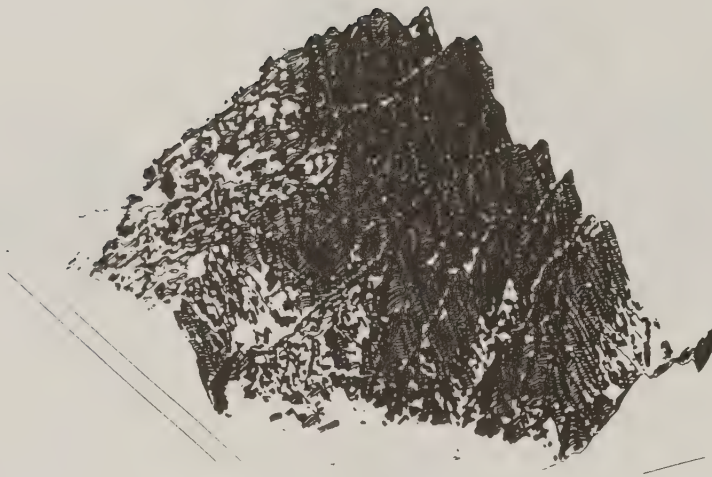
AS WE SIMULATE THE FUTURE, THERE WILL BE SEVERAL SCENARIOS USED TO UNDERSTAND FUNCTIONS AND ENERGY FLOWS MORE SPECIFICALLY. ONE FUTURE SCENARIO COULD BE WITHOUT FIRE (assumed continued suppression by man), ANOTHER WITH NATURAL FIRE IGNITIONS, OR ANOTHER WITH OR WITHOUT INSECT AND/OR DISEASE EPIDEMICS ON THE VEGETATION COMPONENTS, ETC. FLMP DIRECTION ALSO IS INCLUDED HERE.



STEP 2A - CURRENT SITUATION -

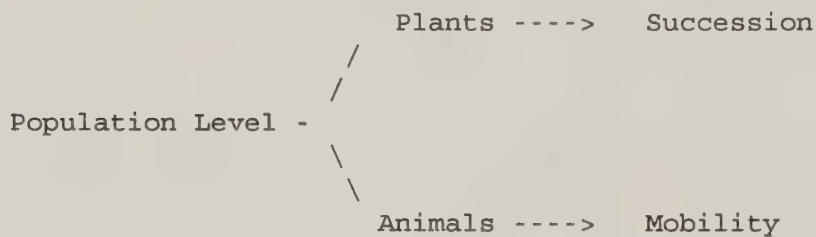
ASSUMING THAT OUR ECOSYSTEM MODEL WILL REPRESENT THE LANDSCAPE LEVEL ORGANISM POPULATIONS, AND NOT THE INDIVIDUAL SPECIES LEVEL, WE WILL DIVIDE OUR MODEL CONSTRUCTION TASKS INTO FOUR EFFORTS: OUR ECOSYSTEM'S COMPOSITION, STRUCTURE, PATTERNS, AND FUNCTIONS (All our answers will have four parts).

STEP 2A-1 COMPOSITION----This is the multi-layer birds eye view the landscape. These layers include vegetation, soils, wildlife population boundaries, slope, geology, etc. Composition can be monitored by predominate composition type and acres. Serial or successional stages are also identified here.



STEP 2A-4 FUNCTION - Is the interaction between spatial elements, materials, organisms, and among components of ecosystems. This interaction may be vertical or horizontal to include wildlife movements and seasonal uses,

Function within Space



Function -Energy Transfer

Function Code

Animal ----> Animal {	Predator	PR
	Parasite	PA
	Competition	CP
	Mutualistic/Complimentary	MU
Animal ----> Plant {	Niches	NI
	Food/Seasonal	FS
	Escape/Hiding Cover	EC
	Thermal Cover	TC
	Migration Corridor	MC
	Poisonous	PO
Plant ----> Plant {	Ecotone	EC
	Edge	ED
	Parasite Host	PH
	Competition	CP
	-sunlight	CS
	-moisture	CM
	-nutrients	CN
	Inhibitors	IN
	-growth	IG
	-germination	IE
	Unknown	UN

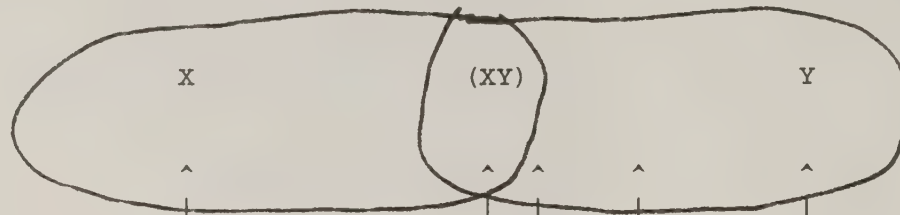
A matrix is constructed to model the FUNCTION concepts. Using GIS the matrix attribute display the spatial relationships between COMPOSITION, STRUCTURE, and PATTERN analysis steps. By starting simple, this concept can be viewed as follows:

Diagram of Functional Relationships

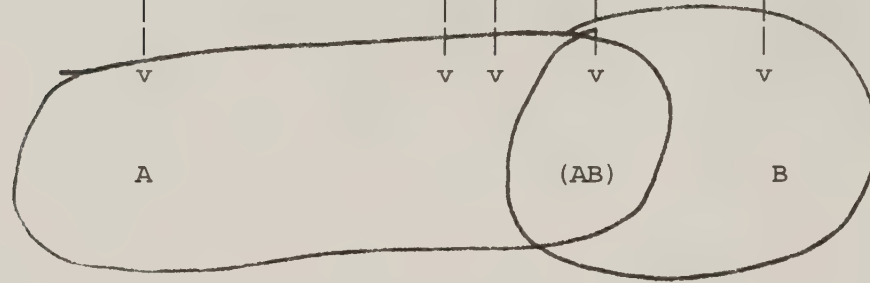
GIS Layer

Attributes

Animal



Plant



Matrix's of Functions

		Animal		
		X	XY	Y
Animal	X	-	CP	UN
	XY	CP	-	UN
	Y	UN	CP	-

Animal to Animal

		Plant		
		A	AB	B
Animal	X	TC	TC	FS
	XY	FS	EC	FS
	Y	EC	EC	FS

Animal to Plant

		Plant		
		A	AB	B
Plant	A	-	CM	UN
	AB	CS	-	UN
	B	UN	CS	-

Plant to Plant

The next step is to expand the GIS layers to represent the principal issues components or organisms to be used in the ecosystem model. When combined in GIS, the intersection of the numerous data layers will form unique cells for which the matrix is expanded to represent the multiple combinations. Functionality coding must also represent unique processes defined in the stratification process in STEP 1. Within the GIS, acres will be used to track function codes.

Expanded GIS Layers

Insect and Disease

Animal 1

Animal 2

Animal 3

Vegetation

Aspect

Slope

Elevation

Soils

Geology

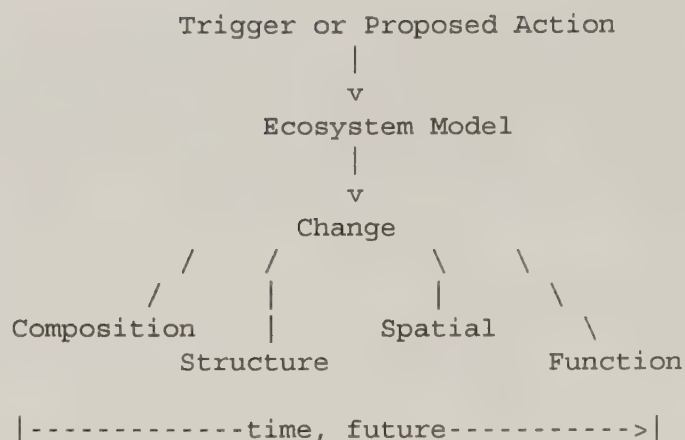
STEP 2B - DEFINE THE PRE ANGLO MAN LANDSCAPE (APPROX. -150 YEARS). REPEAT THE COMPOSITION, STRUCTURE, PATTERN, AND FUNCTION MODELING USED IN THE CURRENT SITUATION. (Note: functional relationships may not change that much, just acres of functions; eg: 1000 acres functioning as thermal cover versus 500 acres.)

STEP 2C - DEFINE THE FUTURE LANDSCAPE. USING ALGORITHMS OR COMPUTER PROGRAMS (AML'S), REPEAT THE COMPOSITION, STRUCTURE, PATTERN, AND FUNCTION MODELING

AS WE SIMULATE THE FUTURE, THERE WILL BE SEVERAL SCENARIOS IN ORDER TO UNDERSTAND FUNCTIONS AND ENERGY FLOWS MORE SPECIFICALLY. ONE FUTURE SCENARIO COULD BE WITHOUT FIRE (assumed continued suppression by man), ANOTHER WITH NATURAL FIRE IGNITIONS, OR ANOTHER WITH OR WITH OUT INSECT AND/OR DISEASE EPIDEMICS ON THE VEGETATION COMPONENTS, ETC. FLMP DIRECTION IS ALSO INCLUDED HERE (DESIRED FUTURE CONDITION).

STEP 3 - USING THE GIS ECOSYSTEM MODEL

STEP 3-1- THIS STEP INCLUDES DEFINITION OF TRIGGERS, PROPOSED ACTION, NEEDS FOR CHANGE, ETC., THAT WOULD SET FORTH EVENTS THAT NEED TO BE EVALUATED WITH THE GIS ECOSYSTEM MODEL. THESE ACTIONS WOULD GENERALLY BE WITHIN FLMP DIRECTION FOR THE LANDSCAPE AREA.



This process uses the Ecosystem model as a baseline. It monitors acres where possible, and uses displays, maps, and projections to model the effects to a dynamic ecosystem through time.

STEP 3-2- BUFFER THE PROPOSED ACTION OR MAP OUT THE EFFECTED AREA AS A RESULT OF THE PROPOSAL. There can be a great deal of variability in this step. Some proposals may be site specific and localized, while other such as management of spatial heterogeneity encompass the entire landscape. A GIS can also be used to identify resource opportunities in defining proposed actions or events as designated by FLMPs, eg:

Objective - select areas within conifer types that are most suitable for round wood production.

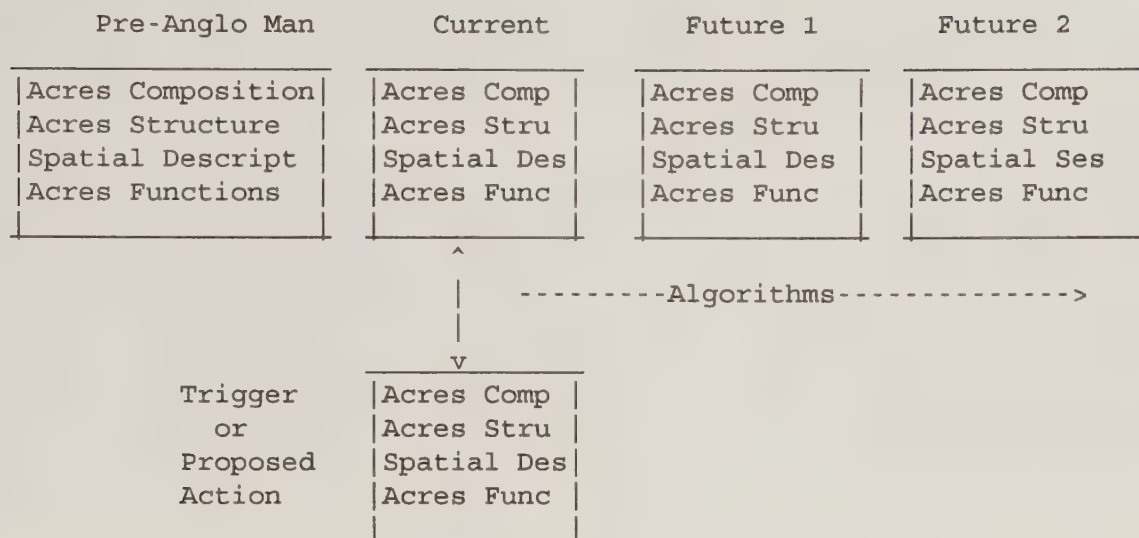
<u>GIS Matrix</u>			Interpreted event
<u>Soils</u>	<u>Slope</u>	<u>Wildlife Habitat</u>	<u>(Suitability)</u>
stable	< 40%	low value	1
unstable	< 40%	low value	3
stable	> 40%	low value	2
unstable	> 40%	low value	2
stable	< 40%	mod value	2
unstable	< 40%	mod value	3
stable	> 40%	mod value	2
unstable	> 40%	mod value	3
stable	< 40%	high val	3
unstable	< 40%	high val	3
stable	> 40%	high val	3
unstable	> 40%	high val	3

Legend: 1 = Highly suited, 2 = Mod. suited, 3 = least suited.

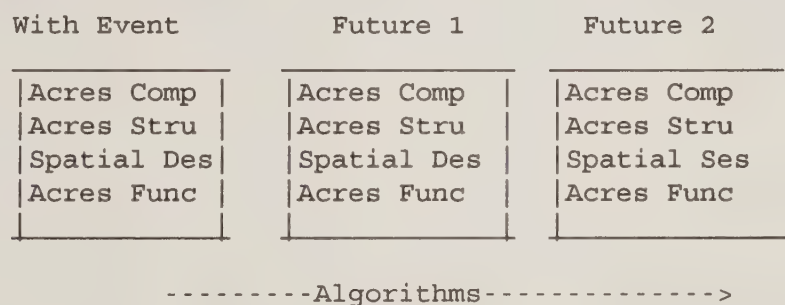
Then the new interpretation of highly suitable areas can be used to evaluate effects with the ecosystem model.

STEP 3-3- UNION THE PROPOSED ACTION OR EVENTS WITH THE BASELINE ECOSYSTEM MODEL (CURRENT SITUATION). THEN USING THE ALGORITHMS DEVELOPED EARLIER, PROJECT THE MODEL INTO THE FUTURE SCENARIOS. The following is a sample summary display for ecosystem effects through time:

Base Line Model



Total Ecosystem Effect and Projected Future(s)

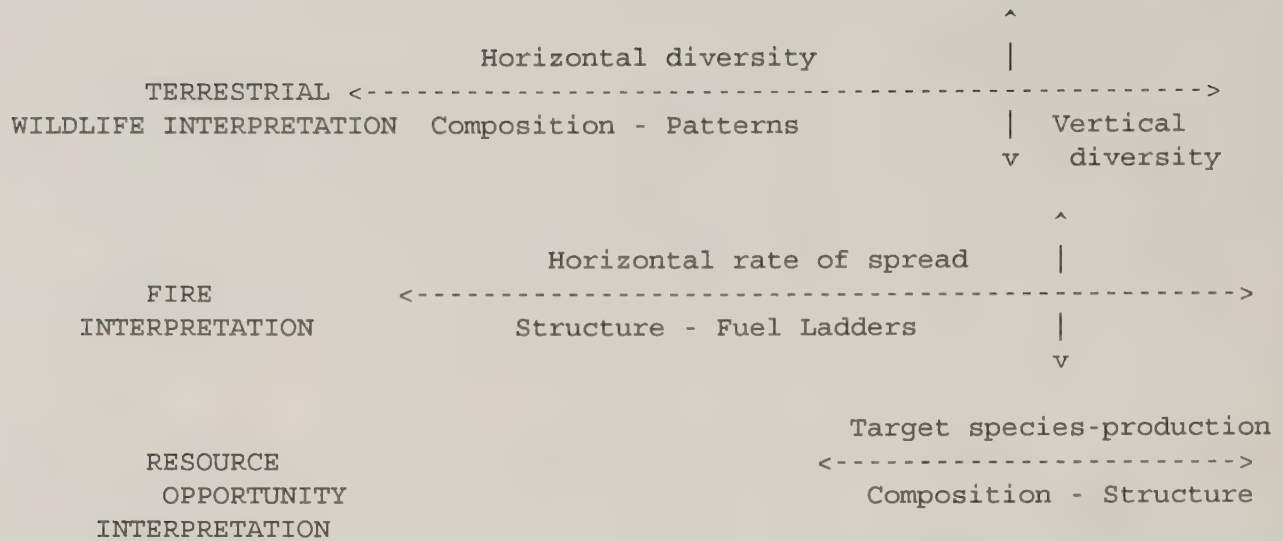


STEP 3-4- ANALYSIS OF COMPOSITION

Compositional changes will be illustrated with GIS products and reports.

STEP 3-5- ANALYSIS OF STRUCTURE

The combination of COMPOSITION and STRUCTURE can represent a cross section of the landscape, useful in many interpretations. For example:



STEP 3-6- ANALYSIS OF SPATIAL PATTERNS

Spatial analysis represents the capability to view the landscape in a 3rd dimension with GIS.

-Look at the ecological effects of these patterns within and among ecosystems. Key considerations include:

- a. Development and dynamics of spatial heterogeneity.
- b. Interactions and exchanges across heterogeneous landscapes.
- c. Influences of spatial heterogeneity on both biotic and abiotic factors.
- D. Consider the management of spatial heterogeneity.

STEP 3-7- ANALYSIS OF FUNCTION

Analysis of functional relationships and their quantitative change will show how spatial elements, materials, organisms, and other components of the ecosystems interact.

DEPENDENCE OF MEAD'S MILKWEED ON GEOLOGY

Andrew H. Rorick
Forest Geologist
Shawnee National Forest

Abstract

Mead's Milkweed (Asclepias meadii), a federally listed threatened species, is known historically to inhabit mesic, tall-grass prairies. In Illinois, only one such occurrence still exists, in Ford County. However, in southern Illinois, at least 400 kilometers south of its tall-grass range, A. meadii occurs on the Shawnee National Forest, in the southeastern corner of Saline County, under extreme xeric conditions in barrens remnants along a sandstone ridge known as Cave Hill. At this location, tectonic events (faulting, uplift and folding of the earth's crust) occurring between 240 and 70 million years ago, created a unique combination of elevation, slope, aspect, and bedrock condition favorable to this rare, very sensitive plant.

The Pennsylvanian sandstone cuesta of which Cave Hill is a part, spans southern Illinois from the Ohio River to the Mississippi River, but only at Cave Hill have tectonic forces shaped the cuesta's physiography: the earth's crust was first sheared and stretched, creating a major fault zone. Then the area was compressed, pushing up by more than 1,000 meters the block of crust adjacent to the fault zone that now forms Cave Hill. Relaxation of compressive forces and millions of years of erosion have finished creating this small, exclusive patch of habitat for A. meadii.

Photographs maps and cross-sections illustrate the tectonic uplift and the bluff-forming sandstone that demarcates the cuesta at Cave Hill, highlighting the dramatic tilting and fracturing of the bedrock. Soil is thin to non-existent along the ridge-line, except in pockets where debris and loess have filled some of the fractures in the bedrock, and soils have been allowed to develop protected from erosion. It is those protected pockets that are the local habitat for A. meadii.

Ten counties in Illinois are known historically to support populations of A. meadii; all except Saline are in the north half of the state. Massive continental glaciers covered most of the northern midwest during the Pleistocene Epoch, the period of geologic time lasting from 2 million to 10,000 years ago. Ice sheets from the last two glacial stages, the Illinoian Stage (300,000 to 130,000 years ago) and the Wisconsinan Stage (75,000 to 10,000 years ago), blanketed most of the state with glacial drift (boulders, gravel, sand silt and clay) up to 140 meters thick. Glaciers from the earlier stage reached to within 10 kilometers of Cave Hill. The later stage covered the northeastern third of Illinois, including Ford County.

Given the 400-km distance between the Ford County population and the one in Saline County, it is evident that A. meadii at the latter location, just south of the deepest glacial maximum, occupy a "refugia" for this species, which had retreated ahead of the drastic climatic changes accompanying glacial advance. Therefore, this location on the Shawnee National Forest is arguably the oldest population center in Illinois.

MULTI-SCALE ECOSYSTEM ANALYSIS

Robert G. Bailey and Peter Avers

Ecosystem analysis is the subdivision of a landscape into ecological mapping units. This poster presents an overview of the theory, design and use of ecological mapping units. Such mapping units delineate similar bio-physical environments for land evaluation and planning and may be defined at various hierarchical scales dependent on management needs. The criteria commonly used in ecological map unit design [e.g., climate, landform, geology, soils, topography and potential plant communities] do not change significantly following management activities. Consequently, they, along with aquatic units (e.g., watersheds, stream reaches), provide a template on which data concerning the existing condition of the the land (e.g., vegetation maps, wildlife surveys) and human elements (e.g., cultural inventories) may be overlaid to facilitate integrated ecosystem analysis. Ecological units provide a consistent basis for predicting what the land could be while other resource maps describe its current condition and history.

The Forest Service has recognized that ecological units are critical to all planning and analysis efforts for ecosystem management. Although some commonality of purpose exists, there is not a uniform set of criteria by which units are defined and mapped. Cooperative efforts are underway to develop common or compatible systems for setting ecological unit boundaries at varying scales in a hierarchy.

CHARACTERIZING FOREST COMPOSITION OF THE ALLEGHENY MOUNTAINS USING EXTENSIVE FOREST INVENTORY DATA: AN OVERVIEW

William H. McWilliams, Rachel Riemann Hershey,
David A. Drake, and Carol L. Alerich
Northeastern Forest Experiment Station, Radnor, PA.

As the USDA Forest Service implements Ecosystems Management, the Northeastern Station, Forest Inventory and Analysis project (NE-FIA) is in a unique position to play a role in landscape-level assessment and monitoring of forest communities in the northeastern U.S. The Eastern Region and the North Central and Northeastern Station's Strategy for Ecosystems Management has proposed a hierarchical system of ecological inventory and classification. The National Forest Inventory and Analysis research group (FIA) is the only Forest Service entity that collects and manages extensive ground-level measurements of forest ecosystems at sample intensities appropriate to the two highest levels of the hierarchy: the province and the section. This poster describes a pilot study aimed at developing a system that integrates NE-FIA's data archive with a recently acquired GIS. It is expected that the system will evolve into a useful tool for characterizing species composition, wildlife habitat, recreation potential, and other landscape-level forest attributes. Inter- and intra-community relationships will be investigated and spatial gradients will be emphasized. Output from the system will provide linkages with forest ecologists working at other levels of the hierarchical scale, the Forest Health Monitoring Program, the Global Change Program, and others.

Sampling and Database Management

The NE-FIA conducts successive inventories of forest resources in 14 states of the northeastern United States. The design of the sample is double sampling for stratification. The first phase involves interpretation of temporary aerial photo points to estimate forest land area and distribute the sample of permanent and temporary ground plots across volume-per-acre strata within each county. Over the years, the sample has included remeasured plots (for trends) and new-ground plots (to decrease statistical error), but the current approach is to remeasure as many plots as possible to improve trend estimates.

The NE-FIA maintains an extensive database containing plot- and tree-level data that include both measured and computed variables. The data are stored and managed using a RDMS (Oracle) with a database designed to contain variables that are consistent among the four FIA projects that cover the eastern U.S., termed the Eastwide Database. The system consists of county-, plot-, and tree-level tables (or relations) that serve as the forest inventory data-link for NE-FIA's GIS.

Geographic Information System

The NE-FIA currently uses ARC/INFO to organize spatial data relating to forest inventory. The NE-FIA GIS integrates data from the RDMS with spatial information managed as layers within ARC/INFO. The main layers used in this study contain sample plot coordinates and physiographic boundaries. Additional layers will be added as the study progresses. Sample plot coordinates come from a file generated during the photointerpretation phase of the inventory.

Fenneman's physiographic boundaries were digitized from an existing national map. The NE-FIA GIS located sample plots within the Allegheny Mountains physiographic section and matched them with coordinates stored in the plot-level table of the RDMS. The plot-level table is linked to the tree-level table using variables unique to a given sample plot. This collection of data was extracted and serves as the sample used to characterize forest composition.

Forest Composition

Characterization of large forested landscapes requires a sample taken from relatively homogeneous ecological habitat. This study examines the composition of forest communities at the physiographic-section level of scale. The approach is intended to overcome the limitations of using political sub-divisions that often dissect natural landscapes and the limitations of combining studies of local conditions that differ in their methodology and intent. An emphasis is placed on variation in composition along latitudinal gradients.

The sample lends itself to assignment of forest community type based on the dominant tree canopy. As a starting point, the NE-FIA's standard typing algorithm generates specific "forest types" based on diameter and crown class. The FIA forest types are related to conventions described by the Society of American Foresters. The FIA types are somewhat limited for ecological assessment because of their all-encompassing nature; naming conventions do not always reflect the species that are present. The opportunity exists to evaluate alternative approaches for assigning forest community type.

The NE-FIA sample measurements contain enough detail to explain the major sources of variation in species composition within the Allegheny Mountains. Plot-level variables include slope, aspect, terrain position, disturbance history, and others. In addition, a variety of importance values are available, such as total tree dry weight, average diameter, numbers of stems, and merchantable volume. This analytical framework provides broad measures of species richness and heterogeneity. As with community typing procedures, opportunities exist to explore a variety of diversity indices and more complex topological relationships among GIS layers.

Refinements and Extensions

Several refinements and extensions of the system described in this pilot study are planned:

- incorporate revisions to Bailey's Ecoregion map (provinces and sections).
- provide a framework for comparing various physiographic and ecological boundaries.
- acquire additional GIS layers for soils, hydrology, topography, U.S. Fish and Wildlife Service (USFWS) digital wetland maps, etc.
- evaluate the performance of various species diversity indices.
- investigate improved forest community type classification techniques.

- fully integrate the RDMS and GIS.
- develop and integrate a satellite image processing capability.
- develop landscape-level forest community profiles for physiographic provinces and sections of the northeastern U.S. and make comparisons between communities.
- investigate the character of forested wetland communities using USFWS wetland maps to delineate wetland boundaries.
- incorporate models for identifying and characterizing wildlife habitat and other critical habitat.

INTEGRATED RESOURCE INVENTORY DISPLAY

United States Forest Service Rocky Mountain Region

The Rocky Mountain Region has developed Integrated Resource Inventory (IRI). Objectives for IRI are to provide ecologically-based integrated resource information; streamline inventories for time, cost and personnel efficiencies; and provide consistent and reliable spatial information for use with Geographic Information Systems.

IRI was tested in 1992 on two small projects. Examples from one of the test sites are shown in this display. The inventory will be done from six Inventory Centers. These Centers are to be phased in over a three year period, beginning in the summer of 1993. Projections are to have IRI completed over the entire Region by 1999.

Integrated Resource Inventory is the integration of three resource map layers: the Common Water Unit, the Common Land Unit and the Common Vegetation Unit.

The Common Water Unit is a hierarchical classification of watersheds and aquatic systems. The three components are streams (lines); lakes, ponds, and aquifers (polygons); and seeps and springs (points).

The Common Land Unit is the integration of landshape, geology, soil, and potential natural vegetation in polygons.

The Common Vegetation Unit is the map layer consisting of existing vegetation (live or dead) in polygons. This is a dynamic layer which will constantly change due to successional processes and disturbance events.

All point data will be located on a separate map layer. Point data includes field plots from exams and monitoring.

The three main layers are vertically integrated, sharing common boundaries where appropriate. The integration produces a GIS-ready product. The hierarchical structure of the inventories allows inventory at any level of detail from Forest Planning to specific project level.

Some applications of the integration of the three layers include: biodiversity analysis; stratification for timber sale planning; stratification for Allotment Management Plans; suitability; productivity; Threatened, Endangered and Sensitive species predictions; and cumulative watershed effects analysis.

The display shows examples of each of these map layers. A map is displayed which shows the integration of the Common Land Unit and the Common Water Unit. Displayed is the riparian areas.

The Vision for IRI in the Rocky Mountain Region:

1. A fully integrated resource information environment supporting landscape and ecosystem analysis.

2. A new way of thinking about inventories. A less functional approach to our view of the landscape.
3. To provide day-to-day resource information needed by resource specialists performing interdisciplinary analysis in an electronic form.
4. To promote dialogue with the public by providing a comprehensive framework for understanding and communicating about resources.

IRI is a significant and meaningful step in demonstrating the Region's commitment to ecosystem management. Never before, in the Rocky Mountain Region, has resource information been integrated to the extent proposed for IRI. The Integrated Resource Inventory will assist the Rocky Mountain Region in becoming a Leader in Ecosystem Management.

VEGETATION INVENTORY FOR NATIONAL FORESTS IN UTAH

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Introduction

A forest inventory is being conducted for the entire State of Utah from 1992 through 1994. The Interior West Resource Inventory, Monitoring, and Evaluation Program (IME) of the Intermountain Research Station is coordinating the inventory, and various aspects of the inventory are being supported by the Intermountain Region, Utah State University, and the Bureau of Land Management and the Fish and Wildlife Service of the U.S. Department of the Interior. Several other organizations provide indirect support.

For the six National Forests included in the statewide inventory, forest stands are being used as sample units. Scattered forest areas, and nonforest vegetation areas on some forests, are being sampled using a point sampling procedure. The forest stand data will be used in forest-level stand data bases, and all vegetation sample data will be compiled at the forest level for management planning and reporting at State and National levels.

Landsat Thematic Mapper Vegetation Mapping

The Fish and Wildlife Service, through Utah State University, is mapping vegetation in Utah in support of their Gap Analysis program (Ramsey and others, 1992). Ground truth data sites are collected during the inventory and through the line organization of several agencies to ensure the quality of the vegetation map. Supporting data layers are derived for ownership, political and administrative boundaries, and landform in digital and polygon format for use in geographic information systems.

Sampling Design

National Forests in Utah are sampled using a sample point grid defined by the Universal Transverse Mercator (UTM) grid system commonly found on quadrangle maps. The sample grid points are at 5,000 m intervals, with a second 5,000 m offset grid to double the sample special interest areas. A stratified two-phase design uses the digital vegetation map to define sampling strata, and sample grid points on the map define the secondary field sample .

All strata are checked on the ground, and at samples found to be forest land, (all vegetation types on some forests) data are collected to describe current vegetation and site characteristics. Forest stands are further sampled with a transect of temporary sample points.

Stand Delineation

If the vegetation map stratum area covers diverse topography, forest stands are further defined within the stratum area using stand structure, water courses, and landform. This procedure usually defines stands averaging about 40 to 60 acres, depending upon the mix of vegetation and landform, with an upper limit of about 150 acres.

Field Sampling

All forested grid points defined as sample origins are sampled using a permanent 5-point subsample cluster. Where nonforest vegetation sites are sampled, a similar procedure is used. Forest stands are sampled with a transect of additional temporary points established on resource aerial photography. Data collected are described in the Utah Forest Survey Field Procedures, 1991-1993, available from the principal author.

Data Compilation

The vegetation type stratum areas from the Landsat Thematic Mapper digital data set are summarized to expand the sample to statistical tables at the forest level. The vegetation type digital map--with supporting digitized ownership, political and administrative boundaries, and elevation data--form a basis for further analysis in a digital geographic information system. The digital data will be shared with other agencies through the geographic information system organization within the State government.

References

Ramsey, R.D.; Born, J.D.; Homer, C.; and Edwards, T.C. 1992. Thematic mapper vegetation mapping for the state of Utah. In: Remote sensing in natural resource management. Proceedings, Forest Service remote sensing applications conference; 1992 April 6-10; Orlando, FL. Falls Church, VA: American Society for Photogrammetry and Remote Sensing: 148-157. (Contact the principal author for a copy of the paper.)

APPLICATION OF THE ECOLOGICAL CLASSIFICATION
AND INVENTORY ON THE OTTAWA NATIONAL FOREST

James K. Jordan, Forest Soil Scientist
Ottawa National Forest

The Ecological Classification and Inventory (EC&I) provides land capability information for various levels of ecosystem management planning and project needs on the Ottawa National Forest.

Landtype Association (LTA) - Forest Planning

Ecological Landtype (ELT) - Forest Plan Implementation
(Opportunity Area Analysis)

Ecological Landtype Phase (ELTP) - Forest Plan Implementation
(Project Design)

For Forest Planning, the LTAs provided broad spatial control for the analysis potential productivity of timber products, wildlife habitat potentials, road costs, logging costs, regeneration opportunities, inherent vegetation variability, and others. LTAs were used in the delineation of the Management Areas in the Forest Plan.

For each Management Area, the Forest Plan established a desired future condition. Within each Management Area, Opportunity Areas are analyzed to identify projects that move the area toward the desired future condition. The ELTs provide spatial information to help display and compare different spatial arrangement options of the desired future condition. ELT information helps to identify project opportunities, long-term road corridors, areas of even-aged and uneven-aged northern hardwoods, areas of other timber products, minimum level management areas, deferred areas, old growth areas, potential Research Natural Areas, and others.

Specific projects are identified through opportunity area analysis. ELTPs provide site-specific spatial information on specific tree species, potential productivity, road and landing locations, logging equipment operation periods, plant competition, Endangered, Threatened and Special Concern plan location and relationships, specific wildlife habitat (i.e. Black Bear model), and others.

OUACHITA NATIONAL FOREST AND THE AQUATIC ECOSYSTEM - A STUDY

Region 8

The first panel describes the Study.

It begins with a definition for aquatic ecoregions and a discussion of how these ecoregions are established on the forest.

Within each ecoregion two watersheds were selected. Both watersheds are primarily NFS lands and of similar size and proximity. One of the paired watersheds was devoid of management activities while the other watershed represented typical management practices that have occurred over the last 30 years.

The second panel describes the Methods.

Using basin survey techniques, the methods are separated into physical, chemical and biological criteria.

A short discussion of each criteria and sampling methods is included on the poster.

Physical measurements are collected continuously along the entire length of the stream. Physical measurements include the identification of stream habitat units as well as a series of physical measurements collected for each habitat unit. Measurements include lengths, widths, depths, substrate, cover, canopy closure and bank stability.

Chemical measurements are stratified along the length of the stream. Measurements include pH, major nutrients, cation, anion, dissolved oxygen, and turbidity

Biological samples are based on physical habitat units. Ten percent of all habitat types are sampled. These samples are stratified along the length of stream. Measurements include aquatic macroinvertebrates and fish.

The third panel describes some preliminary results.

The results for each criteria are displayed graphically with a short discussion.

Canopy Closure (a physical measure) is depicted along the Bread Creek (managed watershed) and S. Alum Creek (control watershed). The variability between these systems is a result of the management activities between them.

Stream pH is depicted as a chemical criteria for the same streams. The gradual increase as you move downstream should be noted.

Fish species richness is displayed for Bread Creek (managed watershed) and S. Alum Creek (control watershed). While a great deal of variability is

noted within stream habitat types, the stream richness between the watersheds is similar.

The fourth panel discusses the Future.

This panel discusses how this type of inventory can be used to address three issues relative to managing the National Forests.

1. Effectiveness and Validation Monitoring of Best Management Practices

Using basin wide survey techniques, we can provide the monitoring link between management practices and the aquatic ecosystem.

2. Desired Future Condition

Using basin wide survey techniques, we can constructively describe and discuss the Desired Future Condition of the Aquatic Ecosystem.

3. Cumulative Effects Analysis for Water Quality and Beneficial Uses

Using basin wide survey techniques, we can determine the cumulative effects or lack of cumulative effects associated with management activities.

THREE GIS DASHBOARDS FOR RESOURCE MANAGEMENT

Alan Clingenpeel and Chris Frye

Abstract: Our GIS dashboards are easy-to-use graphics based GIS tools, specially designed for field level resource managers. Dashboards will help our specialists in the natural sciences, earth sciences and social sciences make better spatial decisions in their day-to-day jobs. These dashboards are composed of multi-level menus that step the operator through complex information retrieval and analysis, as well as "pushbuttons" that perform specialized functions required by the user.

The three GIS dashboards we will demonstrate are for use in aquatic, bird habitat, and cultural resource analysis. We invite you to try your hand at our dashboards at our exhibit table!

Background information:

GIS in the Southern Region

Milestones in the Southern Region's GIS program, which began ramping up in 1986, are:

- 1988 -- Contract for first GIS database initiated (at TVA)
- 1989 -- First Ranger District vertically-integrated GIS database produced
- 1989 -- R-8 GIS Implementation Plan published
- 1990 -- First GIS Application Note -- GIS use in timber salvage for Hurricane Hugo
- 1991 -- First GIS "Dashboard" begun (hydrology)
- 1992 -- Hydrology, Bird Habitat, and Archaeology prototype dashboards completed

Regional Status - As of today, 37 out of 105 Ranger Districts in the Southern Region have completed GIS databases. All 105 databases will be completed by FY 1996. These databases are currently maintained in Arc/Info on 16 PC and 10 Unix workstation platforms distributed throughout the region.

What's in the GIS? - Basic information layers in every district GIS are soils, roads and trails, streams, waterbodies, land lines, administrative area boundaries, compartments, and stands. Many districts have opted for additional information such as VQO's, geology, T&E species, and contours.

What's "Vertical Integration"? - A keystone of R-8 databases is the "vertical integration" of their basic layers. Vertical integration maintains the crucial logical relationships of geographic features. For example, a property line that is also a compartment line and a stand line exists as a single "smart" line in our GIS, rather than three separate lines that could wander away from each other.

PLAGUES AND PESTILENCE ACROSS THE LANDSCAPE

Brian W. Geils and John E. Lundquist

Tree-killing insects and pathogens are significant disturbance agents that influence the dynamics of ecosystem processes and productivity of forests for numerous amenity and commodity products. Therefore, scientists at the Rocky Mountain Forest and Range Experiment Station are developing analytical methods to address Forest Health issues and to support Ecosystem Management policy. Our studies identify forest conditions that affect risk and hazard from insects and diseases, quantify their beneficial and detrimental effects, and develop models to predict their spread and intensification. To bridge spatial scales from the patch to the landscape, we are constructing canopy gap profiles and identifying successional pathways that describe tree decline, death, decay, and replacement. This ecological perspective facilitates design of inventory and prediction methods that better integrate insect and disease information into project and forest planning efforts.

To adequately address present conditions and future trends, forest inventories must include information on the distribution, abundance, and impacts of forest insects and pathogens. Although specific requirements vary with circumstances, integrated resource surveys should capture: 1) the hierarchical structure within landscapes; 2) alternative successional pathways and disturbance histories; 3) dynamic linkages between populations of various species; and 4) the influences of climate, soil, and landform on forest community development.

THE EFFECTS OF A CATASTROPHIC FIRE ON THE PATCH DYNAMICS OF VA
MYCORRHIZAE AND BIOGEOCHEMICAL CYCLING OF NUTRIENTS IN
PINYON-JUNIPER WOODLANDS

Carole Coe Klopatek and Jeffrey M. Klopatek

When viewed from above, the results of a forest fire appear devastating. As a result, determining fire effects has traditionally concentrated on what takes place above-ground. But, the overall effects of fire on forest ecosystems are complex, ranging from reduction of above-ground biomass to impacts in soil microbial processes. Biogeochemical cycling of nutrients and nutrient uptake by mycorrhizae are two of the fundamental mechanisms underlying large scale ecosystem behavior. Presented are the short-term ecological effects of fire on nutrient cycling and VA mycorrhizal (VAM) distribution, density and diversity in this woodland. In an earlier microcosm study, we found that after a simulated fire, VAM colonization was reduced when burning temperatures were above 40°C and eliminated at 90°C. We wanted to determine if these results were representative under field conditions. In fall 1989, 1 ha of mature pinyon juniper was burned using drip torches. All material, including living, downed, and dead matter was ignited. Soil cores were taken from interspaces and beneath canopies of pinyon and juniper in the spring of 1989, and immediately prior to, and 96 hr following the burn. Post-burn soil cores were not taken until 96 hr after the burn because of burning trees and smoldering duff. Soils were then brought back to the laboratory for analysis.

In the spring, there were no differences in mycorrhizal species richness under pinyon, juniper canopies or interspaces. Glomus fasciculatum and G. aggregatum were the two most frequently observed species. Immediately before the burn (pre-burn samples), species richness was slightly lower than in spring in each of the three cover types. Post burn, G. fasciculatum, G. deserticola, and G. macrocarpum were the only remaining species. VAM spore density varied under pinyon, juniper, and in interspaces during spring and pre-burn samplings. Post-burn spore numbers were significantly reduced particularly under tree canopies (up to 88% loss) as compared with the interspaces (47% loss). In a bioassay, percent VAM colonization of pearl millet was significantly ($p < 0.01$) greater when grown in interspace soils than in the other two cover types. All post-burn bioassays were significantly ($p < 0.01$) reduced, and several of the individual canopy soils had no mycorrhizal colonization. Overall losses under canopies were higher (up to 81%) than in interspaces (34%).

Significant losses in nutrients also occurred following burning. Over 75% of the carbon and nitrogen were lost from the forest floor. Nutrient losses under canopies were significantly greater than in interspaces. Loss of nutrients and mycorrhizae were negatively correlated with soil temperature and heating duration, which varied with the amount of litter (and duff under tree canopies) burned and subcanopy position. The highest fire temperatures were reached in soils under canopies (up to 282°C for pine and 237°C for juniper at -10cm).

The large fuel load, in addition to the total combustion of organic material, contributed to a more intense burn. Smoldering of duff and tree stumps maintained these high temperatures for several days. Because interspaces had a low fuel load - little aboveground vegetation, litter, no duff - overall burning temperatures were lower (up to 60°C at -5cm). Overall, the natural

mosaic configuration (canopy/ interspace) leads to a multidimensional "patchwork dynamic" of mycorrhizal and nutrient distribution following fire. Thus, in order to fully comprehend how fire effects an ecosystem, it may be necessary to include long-term monitoring of these essential below-ground processes.

DISPLAYING AND MONITORING THE RELATIONSHIP BETWEEN PEOPLE AND THE LANDSCAPE

Inga Petaisto, R-3, Prescott National Forest

Landscapes may be perceived at many levels: an individual tree; a unit with common vegetation & land characteristics; a mosaic of different vegetation/land/water units; a watershed consisting of a drainage basin and topographic divides; an entire Region covering both public and private lands; or the whole Earth including the layer of air overlying the land and seas. Each organism is a complicated entity that cannot be separated from its environment- "life" is a function of the two together. For example, how long could man live without air, water, sunlight, animals, plants, and microbes? The land, however, does not belong to Man. We belong to the Land.

Traditionally, land management has leaned toward economic, human-centered, development. An ecological perspective embraces humans and other organisms as equal members of a community. A socially sensitive, ecological perspective strives for harmony between human society and nature. Environmental protection and economic development can co-exist if we share this responsibility with scientists and citizens in all aspects of decisionmaking and implementation.

Our future viability depends on intelligence, adaptability, and the recognition that we all are in this together.

Ecology, the science of the interrelationships between organisms and their environments is more complex than we can understand. Not only is the landscape constantly changing, but the human population is growing exponentially. The demands and needs for resources are increasing and values are ever changing.

How can we balance society's requirements while preserving the planet? In the midst of overwhelming complexity, computers will play a key role in combining social and economic dimensions with biological, physical, and chemical aspects. Each landscape has characteristic patterns of biological processes, abiotic factors, and disturbances. Computer images of landscapes and conditions will display the consequences of alternative human activities, alerting managers to dangers and opportunities that our limited sensitivities would otherwise miss. An understanding of patterns and processes at several scales is critical for maintaining biodiversity and for preventing irreparable ecosystem damage.

Comprehensive computer models will evaluate the social, economic, and environmental consequences of alternative actions to meet human needs for energy, chemicals, housing, communications, packaging, and other products. Public and private landowners will participate on Ecosystem Management Councils to maintain ecosystem richness, distribution, and connectivity and preserving the esthetic characteristic of a regional landscape. Direct income and tax benefits will far outweigh the loss of independence involved in membership. Land use allocations will allow certain areas to be managed for resource production and a broad spectrum of benefits while other areas will remain "fallow"- regenerating themselves. After 100 years or so, these management and "fallow" areas will rotate for periods of non-use and relatively intensive use.

The ecological/social perspective is an ethical way of forging a new understanding of the relationship between humankind and earth. It requires courage, passion, and humility to leap forward and develop local, regional, national, and global strategies to conserve biological diversity at multiple scales, multiple ownerships, multiple time periods, multiple factors, multiple values, multiple uses, multiple viewpoints, multiple options, and multiple tools.

ECOLOGICAL CLASSIFICATION and INVENTORY SYSTEM
for
MIDWESTERN and NORTHEASTERN UNITED STATES
(U. S. FOREST SERVICE, REGION 9)

Walt Russell, Regional Soil Scientist
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Introduction:

Managing ecosystems is a primary emphasis of forest resource management in the '90's. Ecological Classification and Inventory (EC & I) is a fundamental prerequisite to managing ecosystems. The USDA, Forest Service, Eastern Region devised a hierarchical EC & I system during the late 1970's, which has been evolving since that time in response to changing values and needs of the American people, with respect to their expectations from their National Forests and Grasslands.

Hierarchical Structure --

THE ECOLOGICAL CLASSIFICATION and INVENTORY SYSTEM (commonly referred to as the Ecological Classification System or ECS) used in the Eastern Region (Region 9) of the USDA, Forest Service, is a **hierarchical** framework, so that Ecological Units can be mapped, displayed, and interpreted at several different levels of resolution (or site-specificity), to respond to different planning and management needs. This "ECS" includes the following hierarchical levels, nested "under" Robert Bailey's Domains and Divisions.

PROVINCE - Multi State

SECTION - Thousands of square miles

SUBSECTION - Tens to hundreds of square miles

LANDTYPE ASSOCIATION (LTA) - Tens to thousands of acres

ECOLOGICAL LAND TYPE (ELT) - Tens to hundreds of acres

ECOLOGICAL LANDTYPE PHASE (ELTP) - 1's to 10's of acres

SITE - Up to about 1 acre

Provinces are the same as the third level of Bailey's EcoRegions, and are based largely on broad climatic regions, modified by physiography. Section criteria is weighed more heavily to broad physiographic regions, influenced by climatic variables, and by mapped broad categories of Potential Natural plant communities, such as Braun's Deciduous Forests of the Eastern United States, Kuchler's Potential Natural Vegetation, and others. Provinces and Sections are currently being revised to fit into the National Hierarchy keyed to Bailey's EcoRegions.

Subsections are currently being developed, in cooperation with several different organizations, based on a variety of existing sources of information

about vegetation, climate, soils, and geology of States and multi-State areas. The Subsections of the three Upper Great Lakes States of Michigan, Minnesota, and Wisconsin, are being developed from the three-State Ecoregion map drafted in 1991 and 1992 by Dennis A. Albert for the Upper Great Lakes Biodiversity Committee.

Land Type Associations (LTAs), **Ecological Land Types (ELTs)**, and **Ecological Land Type Phases (ELTPs)**, are developed and mapped at the National Forest level, and used for Forest Planning and in various phases of Plan implementation. **Sites** are rarely mapped, only where need for very site-specific ecological information is identified. Sites serve as data collection units, reference points, and building blocks for the higher levels in the EC & I system.

A very important feature of the EC & I system is **integration**. Ecological Types and Ecological Units at all levels are based on an integration of **multiple factors**, both biotic and abiotic. The focus is on the integrated land unit, not on any one of the components.

Where do we go from here?

The EC & I system was introduced to the Eastern Region of the Forest Service during the 1970's. Considerable evolution in it's development and application has taken place since that time. The system continues to evolve today, in response to advancing knowledge and understanding about ecosystems, and changing values and needs of the American people, with regard to their expectations from their Forest and Range lands.

As we move in time through the 90's, some **emphasis areas** are:

- Ecological Classification and Inventory of **Aquatic ecosystems**, to compliment previous and current work in the terrestrial arena.
- Further development of the **subsection** level, to provide information necessary for managing ecosystems across large areas.
- Improve **needs assessments** for various hierarchical levels of Ecological Classification and Inventory, to respond to different scales of planning and management.
- Increase partnerships** with other organizations, (both government and non-government) to work toward more cooperation and coordination of efforts in Ecological Classification and Inventory.
- Increase coordination** with other Regions, and with the Research and State and Private Forestry arms of the Forest Service.

AN ECOLOGICAL CLASSIFICATION FOR THE CENTRAL HARDWOODS REGION:
THE HOOSIER NATIONAL FOREST

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The Forest Service and Purdue University have cooperatively developed an Ecological Classification for the Hoosier National Forest. This study, a multifactor ecological classification system, using vegetation, soil characteristics, and physiography was developed for the landscape of the Hoosier National Forest in Southern Indiana. Measurements of ground flora, saplings, and canopy trees from selected stands older than 80 years were subjected to TWINSPLAN classification and DECORANA ordination. Physiographic and soil measurements were regressed on ground flora DECORANA scores. Strong relationships were observed between vegetation, slope aspect, soil A-horizon depth, slope position, and soil pH. The landscape was divided into ecological units called ecological landtype phases (ELTPS) on the basis of these relationships. Thirty ELTPs were identified across the Hoosier National Forest. These thirty ELTPs fit well within and relate to the upper hierarchical levels for the Hoosier National Forest. This Ecological Classification provides a hierarchical framework for identifying and classifying ecologically similar land units for the inventory and management of ecosystems and the functional relationships among them. With the improved understanding of ecosystem structure and function ecologically based forest management strategies and decisions can be made more reliable at the site and landscape level. Results presented are based on examination of 208 sites representing the range of physiographic types on the Hoosier National Forest. An evaluation of methodology and species-site relationships will be presented.

ORGANIZATION AND FUNCTION OF THE NATIONAL SOIL SURVEY CENTER
U.S.D.A. Soil Conservation Service, Lincoln, NE

Ron Bauer
SCS

The National Soil Survey Center is an entity of the Soil Survey Division, Soil Conservation Service, U.S. Department of Agriculture.

Soil Survey Division. "The mission is to assist mankind in the understanding and wisely using soil resources to achieve and sustain a desirable quality of life by maintaining a strong scientific basis for defining and describing soil relationships important to the decisions about the use and management of soils; providing scientific expertise to identify, classify, map, and interpret soils; making field and laboratory information and its interpretation readily available through texts, maps, and other forms of data bases; and by assisting people to apply this information."

The National Soil Survey Center is located in Lincoln, Nebraska. It is composed of five staffs which have national responsibilities for policy and procedures for their particular area of specialty. The Soil Conservation Service has leadership responsibilities for the federal portion of the National Cooperative Soil Survey (NCSS). The five staffs of the National Soil Survey Center (NSSC), are the Quality Assurance staff, Soil Classification staff, Interpretations staff, Soil Geography and Information staff, and the Soil Survey Laboratory and Investigations staff.

Soil Survey Quality Assurance Staff. Assures the quality of soil survey mapping and manuscript preparation in the states. Assists states in producing technically sound, consistent, readily available soils information. Provides for technical oversight, quality assurance and coordination for soil correlation, soil series descriptions, soil interpretations, soil classification, soil survey manuscripts, and soil map compilation. Edits and publishes soil survey reports.

Soil Classification Staff. Controls the evolution of soil taxonomic system. Improves the system to clarify definitions and computations, domestically and internationally. Assists states and cooperators in preparing proposals to amend Soil Taxonomy and maintain taxonomy in an up-to-date usable form. Trains in soil classification. Maintains Soil Survey Manual and prepares and revises Soil Survey Field Handbook.

Soil Survey Interpretations Staff. Develops policy for the direction, structure, procedures, and standards for interpreting and delivering soils information. Works with other specialists including but not limited to: agronomists, engineers, foresters, range scientists, and water quality specialists. Coordinates with the SCS National Technical Centers' soil staffs in developing technology transfer methodology and training users in the application of soil information. Maintains the interpretations parts of the National Soils Handbook (NSH). This includes the rating guides and criteria used for soil surveys and for Field Office Technical Guides. Maintains liaison with the Statistical Laboratory at Iowa State University where the Soil Interpretations Records (SIR) are stored and rating guides are applied.

Soil Geography and Information Systems Staff. National responsibility for automated soil information systems. Responsible for the structure and modification of spatial and attribute databases in line with federal, SCS, and Soil Survey priorities. Coordinates the designs of soil automated databases and works with SCS Information Resources Management in choosing new hardware-software combinations for automated work in states. Provides instructions and training to SCS Technical Centers, states, cooperators of the NCSS, and others in how to use the soil information systems. Works with digital soil geographic databases and develops soil information delivery systems. Maintains the State Soil Survey Database (SSSD) hotline and the National Soil Geography database (NATSGO) and coordinates Soil Survey Geography database (SSURGO), State Soil Geography database (STATSGO), and the National Soil Database housed at the Statistical Laboratory at Iowa State University, Ames, Iowa. Coordinates soil data management development of the National Soil Information System, (NASIS) with the SCS Technical Information Systems Division, (TISD) located in Fort Collins, Colorado. Has responsibility for the maintenance and improvements to the system of Land Resource Regions and Major Land Resource Areas.

Soil Survey Laboratory and Investigations Staff. Provides reliable, new information and understanding about soils, soil relationships, and soil survey methods. Develops and provides soil characterization data; improves characterization methods; develops new concepts, methods, understanding, predictions, of soil behavior and information in support of soil survey interpretations and modeling; and develops information, theories, and understanding about formation of soil, genetic factors, and landscape relations in support of soil mapping, soil classification, and soil correlation.

A NATURAL TERRESTRIAL COVER CLASSIFICATION FOR GAP ANALYSIS

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Introduction

Gap Analysis is a U.S. Fish and Wildlife Service research effort that seeks to identify the degree to which all native plant and animal species and natural communities are or are not represented in our present-day overall mix of conservation lands. Those species and communities not adequately represented in areas that are being managed for the long-term persistence of native species constitute conservation "gaps." Gap Analysis is the first state- and national-level attempt to complete the following, at resolutions usable by land managers, policy makers, planners, and scientists:

- * map all existing vegetation cover types to the dominant/co-dominant species level;
- * predict present distributions of all native vertebrate species;
- * determine extent and importance of places of native species richness;
- * compare distributions of vegetation communities with existing land uses;
- * compare places of species richness with existing land uses;
- * provide an objective basis for a national biodiversity management strategy.

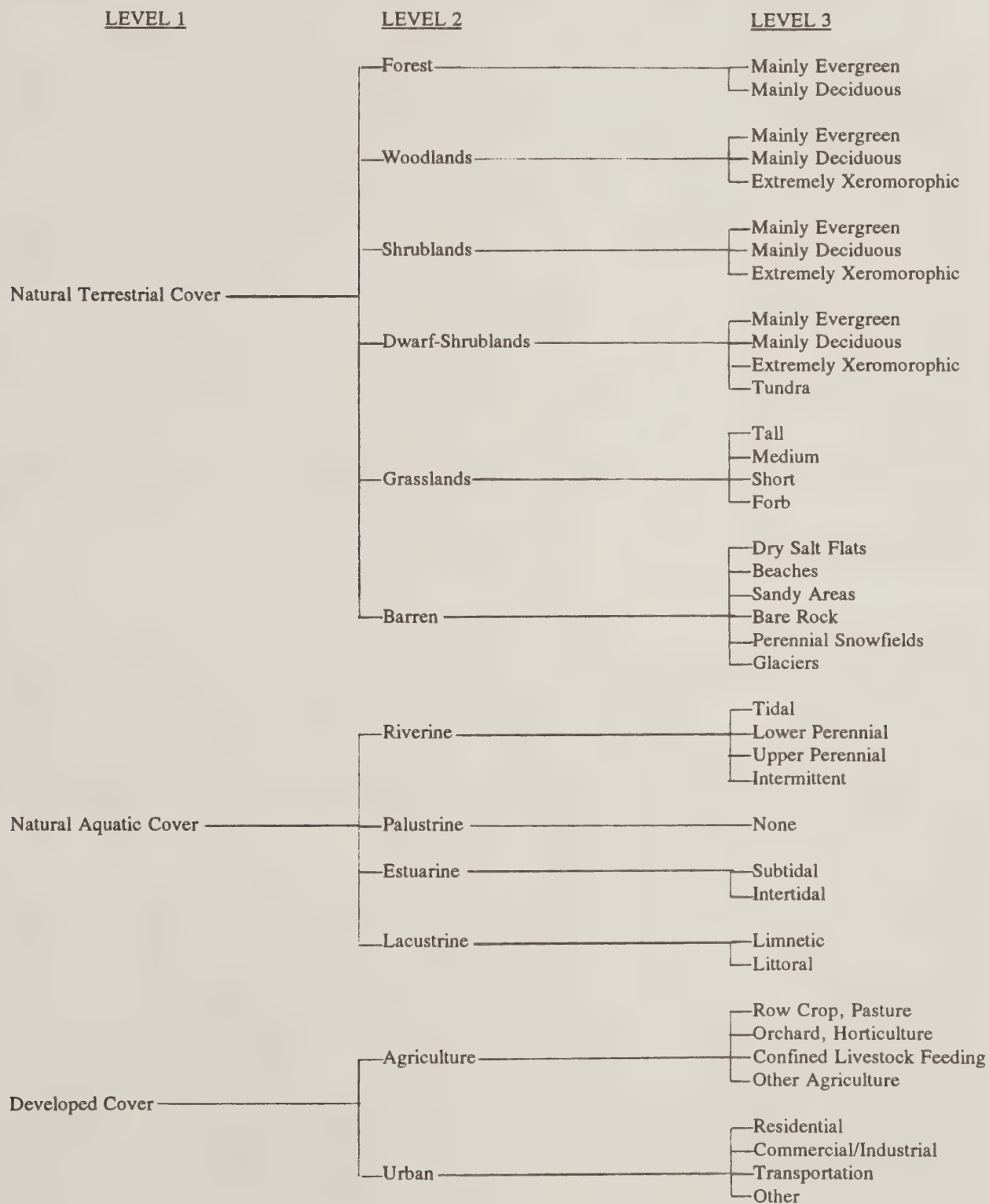
This poster introduces the overall land and water* classification system and provides an overview of its natural terrestrial cover component in particular. A full description of the Gap Analysis concept and process is described by Scott and others (1993).

The land and water classification system for Gap Analysis consists of three primary categories, each of which is subsequently classified according to the following systems:

- a) natural terrestrial cover is classified by the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 1973) system as modified for the United States by Driscoll and others (1983, 1984) and by Jennings (1993);
- b) natural aquatic cover is classified by the system of Cowardin and others (1979);
- c) cultural, or developed, cover is classified by the system of Anderson and others (1976).

The Gap Analysis cover classification system has been constructed to both fit with other major land inventory projects, such as the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program, and to serve the needs of the National Gap Analysis mission. The first three levels of the classification system are presented in Table 1

Table 1. A land and water classification system for Gap Analysis.



Classification of Existing Natural Terrestrial Cover

Gap Analysis seeks to map the extent and distribution of existing vegetation and barren areas in order to:

- a) determine species and natural community representation within areas being managed for biodiversity conservation;
- b) provide spatial data that can be used to model wildlife habitat distributions; and
- c) provide a single temporal data set for later comparison.

To do this, areas of similar plant species composition and* structure must be delineated, identified, classified and labeled. For natural terrestrial cover the Gap Analysis project has chosen the UNESCO (1973) format, with the addition of lower levels and class distinction criteria parallel to those developed by Driscoll and others (1983, 1984; an Interagency Agreement related to classifications and inventories of natural resources, between USDA Forest Service and Soil Conservation Service, and USDI Bureau of Land Management, Fish and Wildlife Service and Geological Survey). Furthermore, although our primary concern with natural terrestrial cover is vegetation, we have added barren as a class-level category to the UNESCO format.

This classification scheme is used because it offers an accepted and useful hierarchical grouping that is based primarily on the physiognomic, or the structural expression of plant cover relative to environment as well as groupings by floristic composition. The physiognomic and floristic classification approach is important for Gap Analysis because it can be related to animal habitat in terms of plant species assemblages, vegetation structure, climate, and plant morphology. For a thorough discussion of the UNESCO classification scheme and the physiognomic approach to vegetation classification see Mueller-Dombois and Ellenberg (1974).

It is important to understand that the UNESCO format as modified for the United States by Driscoll and others (1983, 1984) was originally meant only to describe potential vegetation at climax stage. The two lower levels (the floristic part) of the modified UNESCO system developed by Driscoll and others are plant "series" and plant "associations." These terms refer to concepts of potential or climax vegetation rather than actual or existing vegetation, and their use as applied to actual vegetation has been the source of some confusion. The terms analogous to "series" and "association" which refer to existing vegetation are "cover type" and "community type" respectively. Because Gap Analysis is concerned with present-day conditions, all terms and concepts need to refer to actual vegetation, whether in seral or climax stages of development. The two lower level floristic categories for Gap Analysis, then, are "cover type", and "community type". This classification system is a way to interpret natural terrestrial vegetation based on a need to describe both physical and phylogenetic patterns. It is a dynamic system that will be improved upon as better understandings of natural systems are achieved. For example, one refinement presently* being pursued by The Nature Conservancy is the addition of an indicator species to the cover type category. That is, within a given cover type the presence of certain plant species express broad-scale environmental variables such as climate, soil, or disturbance regimes. Although the occurrence of these indicator species do not constitute units of the next lower category -- "community types" -- the environmental

patterns they represent could be of great significance. Based on the outcome of this work it may be appropriate to further revise the "cover type" category to include indicator species.

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AN INTEGRATED INVENTORY OF THE COPPER RIVER DELTA, CORDOVA, ALASKA

by

Dean F. Davidson

Abstract

In 1964 a major earthquake lifted the Copper River Delta an average of six feet. Since a large portion of the delta was originally affected by the ocean tides or just above the affect of the tide, this uplift initiated a drastic change in the soil properties and development, and in the plant succession. Areas that did not have vegetation prior to the uplift started to colonize. Areas that were originally poorly drained due to tide inundation instantly became somewhat poorly drained or moderately well drained. The vegetation responded proportionally by leaping from herbaceous communities through the shrub stages and in some cases into the beginning of a forest community in a matter of 10 to 20 years. Since the delta is a major wildlife and waterfowl area, the quickly changing habitats were of grave concern. To describe and monitor this change a project was designed which would describe landforms, soils, and the corresponding plant communities at different stages in their succession and use the apparent trends to predict composition and rate of change to new plant communities and wildlife habitat for different soils and landforms.

An Integrated inventory of the Copper River Delta was initiated in 1984 and the collection of data completed in 1989. All field data was collected by a team consisting of a soil scientist, an ecologist, and sometimes a wildlife biologist. This provided for integration of ideas and mapping unit description in the field. Transects across premapped landforms were used to collect vegetation species and cover percentages using the Daubenmire method. This data was analyzed using the Twinspan cluster analysis computer program. Representative soils were described for each of the transects and landforms and compared to the identified plant communities. Landform and soils were used as a mapping base to provided a constant land unit upon which the changes in vegetation could be monitored and hopefully predicted.

The vegetation analyses from Twinspan runs were interpreted in two ways; the first considered the community associations separated by the clustering and decided if there was significant differences between the groups to warrant separation. The second interpretation separated the landforms within the clusters and examined the community association form each landform. The results were only partially successful because of the lack of sufficient samples on each of the landforms representing various stages of vegetation succession. The primary division of vegetation samples were groupings that contained *Carex lynbyaei* or other grasses and sedge, and the groups with a true overstory of woody vegetation.

The statistical analysis program, SAS, was used to examine the soils data and to conduct preliminary regressions of specific species against the soil characteristics. Although few strong correlations were observed, the program did allow us to look at trends in the soil characteristics for the different landforms.

The results of the vegetation analyses indicated that the limited number of samples did not allow us to predict the vegetation communities that would appear on different landforms at different successional stages, but they do provide us with the basis to hypothesize what these relationships appear to be. The results did illustrated how relatively stable plant communities of certain landforms were apparently successional stages on other landforms. The vegetation samples taken from each of the landforms also illustrated the variability in species composition.

The poster presentation on the integrated inventory illustrates the process and the product through which the mapping units were identified using landform, soils, and vegetation on aerial photos, recorded in the Geographic Information System (GIS), and identified and sampled on the ground. It shows two examples of mapping unit identification from two levels of hierarchy; Outwash Plains further delineated into River Bars, Depositional Terraces, River Flats, and Flooded Floodplains; and Marine Deltas further delineated into Slough Levees, Pond Fringes, and Tidal Flats. For each of the mapping units there is brief description of the major soil and landform properties, the most common vegetation, and the importance for wildlife habitat.

MAPPING POTENTIAL VEGETATION USING DIGITAL TERRAIN MODELS

Jan A. Henderson

Area Ecologist, Mount Baker-Snoqualmie and Olympic National Forests

A series of models is being built which uses USGS Digital Elevation Models (DEM), Ecology plots and empirical relationships to map units of Potential Natural Vegetation (PNV). It runs on the ARC/INFO - GRID platform as a set of interactive mapping models. The model structure uses a set of algorithms to generate several basic ecological layers including: Ecozone, Mean Annual Temperature, Topographic Moisture and Cold Air Drainage Effect. In addition, Elevation and Slope aspect, Slope steepness and Slope shape are generated from the DEM's.

These layers then form the basis of a two-step process to: 1. Map Potential Vegetation Zone (VZ) and 2. Map Plant Association Group (PAG).

The Potential Vegetation Zone model uses Ecozone, Elevation, Aspect and Cold Air Drainage Effect to predict the upper and lower boundaries of the major Vegetation Zones for an area (USGS Quad, National Forest etc.) The VZ map is verified by overlaying sample plots from the Plot Data Layer and by field verification. The second stage uses VZ, Ecozone, Topographic Moisture, Elevation and Aspect in a lookup table format to select the most probable Plant Association Group on a pixel by pixel basis. The resulting pixel map can be vectorized and overlaid with the plot data layer to verify the PAG. All coefficients in the model algorithms are "hot" on-screen and can be adjusted interactively to calibrate the input data layers or the output maps.

This modeling approach is being developed and tested on the Mt. Baker-Snoqualmie National Forest in Washington.

THE CHATHAM AREA ECOLOGICAL CLASSIFICATION AND RESOURCE INVENTORY AN OVERVIEW

Chatham Area, Tongass National Forest, Alaska Region
by Steve J Paustian, March 1993

Introduction

This paper is an overview of concepts, classification hierarchies, and mapping and inventory approaches for terrestrial-aquatic ecological unit inventories developed on the Chatham Area, Tongass National Forest. The purposes of ecological classification are to provide "a uniform ecosystem framework for use in land and resource management analysis and planning and to develop an ecologically based information system to aid in evaluating land capability, interpreting ecological relationships, and assessing effects of management" (Avers and Schlatterer, 1991). The Chatham Area ecological inventory program has been successfully utilized in a wide range of landuse planning and resource management analysis applications.

The Chatham Area Ecological Unit Inventory is based on geologic, landform, soil resource, water resource, aquatic resource and vegetation data. This information is organized in a geographical information system (GIS) format that can be used by planners and land managers to locate, compare, and select suitable areas for major kinds of land use activities; to identify areas that need more intensive investigation; to evaluate various management alternatives; and to predict the effects of a given alternative on resource health.

Classification Hierarchies

Broad level ecological classification has had few applications in the Alaska Region to date. Most forest planning applications of the terrestrial component (TEUI) of the Chatham Area Ecological Unit Inventory are focused on landtype scale classification. The aquatic ecological unit (AEUI) inventory component utilizes 10 Hydrologic Units (USGS, 1987) as primary data storage elements for regional hydrologic and climatic data. Most forest planning applications of the AEUI is focused on the watershed and stream segment scale of the classification. At this time, lakes are not an integral part of the aquatic inventory and classification. In the future, lakes and ponds will be incorporated into the AEUI framework. The primary levels of the Chatham Area terrestrial and aquatic ecological unit hierarchies are outlined below.

A. Aquatic Ecological Unit Framework

I. Watershed.

Watershed polygons provide a linkage between the major functional components of a stream network. They are the logical landscape units for analyzing exchange of energy and material within stream networks. Watersheds are a basic data storage compartment for hydrologic, water quality, riparian habitat and aquatic habitat data. Chatham AEUI utilizes a refinement of the National Hydrologic Unit coding system that delineates watersheds and sub-watersheds down to a 3rd order stream network (FSM 2513.2).

II. Process Group (Level 1 Association, Parrott et al, 1989)

Process groups describe the dominant fluvial process acting on a given stream segment. These are functional units that help describe the interrelationships between stream flow regimen, watershed relief, erosion and deposition. Process groups are closely linked to landscape units defined in the TEUI. Classification of process groups is based on associated landforms, channel containment and average channel slope.

III. Channel Type (Level 2-3, Stream Type/Reach, Parrott et al, 1989)

Channel types are stream segments with similar characteristics, defined by morphologic attributes such as channel pattern, channel width, stream bank incision, substrate composition, and stream gradient. These abiotic factors strongly influence the composition and distribution of aquatic habitats and riparian vegetation communities associated with a given stream segment. Riparian vegetation communities are also used to discriminate between Channel Type Units due to the influence of riparian vegetation in shaping and maintaining flood plains and stream channels.

IV. Hydraulic Unit (Level 4, "Hydraulic Unit", Parrott et al)

Hydraulic unit classification uses criteria for depth, flow velocity, and bed roughness to define discrete units that relate directly to biotic capability of small inchannel features (pools, riffles, glides). Hydraulic unit composition is determined by field measurement. These units are typically not mapped however, site specific data are attributed to stream segments defined by channel type boundaries.

B. Terrestrial Ecological Unit Framework.

I. Geographic Province (Subregion Level, Draft National Hierarchy 3/93)

A total of 7 geographic provinces are defined for the 16 million acres of the Tongass National Forest, encompassing most of the Alaska Panhandle. These units are broken out primarily using regional climatic and geologic criteria.

II. Order 4 Landtype (Landtype Level, Draft National Hierarchy 3/93)

Map units are delineated on 1" to the mile aerial photos, using landform groupings that may extend over a 100 to a few 1000 acres in size. Relief, landsurface form, drainage dissection and major elevation breaks are the primary design criteria for these units. Soil complexes are described at the Family level (Order 4 Soil Survey). Only major vegetation cover types (alpine, forested, peatlands) are described at this level of classification.

III. Order 3 Landtype (Landtype Level, Draft National Hierarchy 3/93).

This level of mapping is on 4" to the mile aerial photos and utilizes relatively discrete geomorphic criteria including landform shape, slope, drainage density, and surficial and hardrock geology. Soils are

differentiated to the series level (Order 3 Soil Survey). Plant association complexes (potential natural vegetation) or forest cover types (existing vegetation) are described at this level in the terrestrial hierarchy. Map unit size ranges from 20 to 200 acres.

IV. Landtype Phase (Land Unit Level, Draft National Hierarchy 3/93).

Landtype phase design criteria are based on local soils and vegetation patterns. These subdivisions of landtypes are used to refine riparian and wetlands mapping interpretations.

Inventory Approach

The Chatham Area Ecological Unit Inventory relies on landform, geology, soils, stream channel, and vegetation characteristics to stratify the landscape into mapping units that reflect ecological processes. The mapping criteria are based upon features that may be directly observed in the field or inferred from landscape and vegetative features identified on aerial photography.

The classification criteria were defined using an interdisciplinary approach to identify key information necessary to make basic resource management interpretations. Landuse planners, foresters, silviculturalists, wildlife and fisheries biologists, soil scientists, geologists, and hydrologists participated in this process. Initial map unit design, class limits and mapping legends were developed by soil scientists and hydrologists. The ecological unit inventory is divided into two parts, a terrestrial component (TEUI) and the aquatic, stream reach component (AEUI). Landtype units form the cornerstone for the terrestrial inventory, while channel type units are the cornerstone of the aquatic inventory. The actual inventory was conducted in three phases.

Pre-mapping Landtypes. Landtype inventory components include: landform, vegetation, surficial and hardrock geology, and soils. Landforms are delineated using quantifiable geomorphic features such as slope, internal relief, slope shape, and drainage density; which provide, in part, a basis for inferring properties of other map unit components including soil depth and soil drainage. Twenty two landforms used in the classification are described in West et al (1993). Vegetation is delineated based on major cover types such as forest, shrubland, meadow or peatland communities. Forested areas are further delineated using crown size, crown closure, and tree height. Potential vegetation is classified using plant associations (Martin, 1989). Existing vegetation is determined from regional timber stand inventory information. Landform/vegetation delineations are grouped by dominant surficial and hardrock geologic types. Geology data is derived from existing geological surveys and inferred from landform and vegetation characteristics. Soil properties (depth, drainage, texture, and development) are all inferred from genetic and morphological relationships between landform, vegetation and surficial geology. These relationships were developed from the soils literature and field reconnaissance. Soils are classified according to Soil Taxonomy (Soil Survey Staff, 1975).

Channel Type Premapping. Channel type map unit design criteria includes landform, channel morphology and riparian vegetation components. Landform classification is used to make gross distinctions between stream channel

segments. Landform, hardrock and surficial geology infer valley slope, channel containment, valley material and channel substrate characteristics. Channel morphology is another key component in the channel type classification taxonomy. Classification criteria including channel incision, stream gradient, channel width, and channel pattern define class limits for stream reach level map units. These characteristics are interpreted from aerial photographs and later verified with field checks. Riparian vegetation is the third component used to classify channel types. The band of vegetation within 200 ft of channel banks is used to classify channel types and various channel type phases. Riparian vegetation may be distinct from plant associations defined for adjacent landtypes (Martin, 1989) due to the limited spatial extent of narrow riparian bands and the temporal nature of riparian plant communities.

Field Checking. After pre-mapping is completed, map units are verified in the field. A representative sample of each map unit is visited, and units are reclassified or boundaries are adjusted as necessary. For landtype units, soil profiles are described and assigned to taxonomic classes, and vegetation plots are sampled to define plant association or community. Channel morphology, riparian plant community and substrate data are collected to verify channel type taxonomic classes. Additional data on fish species utilization, large woody debris, and habitat units may also be sampled in conjunction with the map unit verification (Bryant, 1991).

Final Mapping. As field checking progresses, aerial photographs are updated to reflect changes in map unit design and map unit boundaries. If field data falls within the class limit criteria for a particular map unit, the premapped unit will remain the same. If a parameter falls outside the class limits, the appropriate final map unit symbol replaces the pre-mapping symbol. Field information is also extrapolated to map units that did not have on-the-ground investigation.

Accomplishments

The TEUI has been completed on 5.5 million acres of the Chatham Area landbase. AEUI mapping has been completed for the entire Chatham Area (8 million acres), and for the entire Tongass National Forest (16 million acres). The Chatham Area Ecological Unit Inventory has been used extensively in a variety of landuse planning applications including the Tongass Landuse Plan Revision, numerous timber sale project plans, large mine development plans and the Pacific Fish Management Strategy (PACFISH). Some examples of planning and resource interpretive models developed from the TEUI and AEUI include timberland suitability, landslide potential, riparian and wetland inventory, anadromous fish capability, sediment delivery and transfer hazard, and timber productivity. The Chatham Ecological Unit Inventory will continue to be improved as more detailed field survey information is gathered, and as additional resource management applications are developed. It will prove to be an invaluable tool for design and implementation of future ecosystem management strategies for the Chatham Area. The Chatham EUI can also be a useful model for development of new ecological unit inventories, both within and outside the Alaska Region.

Literature Cited

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Martin, J.R., 1989. Vegetation and Environment in Old Growth Forests of Southeast Alaska: A Plant Association Classification. M.S. Thesis, Arizona State University, 221 pp.

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INTEGRATED ECOLOGICAL AND RESOURCE INVENTORIES WORKSHOP

Crescent Hotel, Phoenix, Arizona
April 12-16, 1993

The purpose of the meeting is to develop minimum standards and guidelines for ecological and resource mapping, ecological classification, inventories, and monitoring to ensure integration, consistency, linkage with the human dimension, and comparability across Forest Service units.

Agenda

April 12 Monday	Introduction and Overview	Crescent Ballroom A
PM 1:00 - 1:05	Opening - Moderator - Pete Avers	
1:05 - 1:15	Welcome - Jose M. Salinas	
1:15 - 1:45	Objectives and Remarks - Jerry SESCO	
1:45 - 2:00	EM Organization and function in WO - Bill Sexton	
2:00 - 2:45	Overview of EcoMap Task Team, and the proposed national hierarchy - Avers	
2:45 - 3:00	Break	
3:00 - 3:30	LMP and Information Needs - Bob Bailey	
3:30 - 4:00	Ecological Inventory and Biological Diversity Assessments - John Probst	
4:00 - 4:30	Human Dimensions Of EM - Greg Super	
4:30 - 5:00	Discussion	
5:30	No Host Social	Phoenix Garden
7:00	What on Earth Have we done to our Forests? - A Brief Overview on Conditions and Trends of U.S. Forests - Doug MacCleery. Crescent Ballroom A. Slide show	
April 13 Tuesday	Emphasis of the day: Physical, biological, and human dimension data and information needs and structure. Crescent Ballroom A. Moderator Janette Kaiser	
AM - 8:00 - 8:30	Issue Paper 1 - Integrated Information Structure - John King	
8:30 - 8:45	Work Group Organization and Function - Janette Kaiser	
8:45 - 10:00	Mini work groups for Issue 1:	

A. Develop a National Standard Business Model for ecosystem management. Use this guide to guide development of a corporate resource inventory data base.

B. Identify changes needed for national information requirements for ecosystem management. What are the minimum ecological and resource inventory layers in a national standard GIS that are needed for planning and analysis at multiple geographic scales? What components are integrated in and between layers?

C. Establish common terminology for ecosystem management. Identify candidate terms for a proposed "National Glossary on Ecosystem Management" Identify reference works, sources of definitions, other relevant glossaries, and proposed definitions that may be used in developing this Glossary.

D. What is the resource specialist's role in maintaining information and quality standards.

10:00 - 10:15 Break

10:15 - 11:45 Facilitated combined topic groups (A-D). Purpose will be to develop a combined recommendation from the mini-groups working on the four topics above.
Group A in Crescent Ballroom A
Group B in Meeting Room I
Group C in Meeting Room IV
Group D in Meeting Room VI

11:45 - 1:00 Lunch

PM - 1:00 - 2:15 Continuation of facilitated combined topic groups.

2:15 - 2:45 Break

2:45 - 4:30 Combined work group reports and facilitated discussion.
Moderator - Janette Kaiser Crescent Ballroom A.
Recorder with flipchart

6:00 - 9:00 Remote Sensing Steering Committee meeting. Crescent Ballroom A - Open to All.
Meeting Objectives
Role and Mission of the Remote Sensing Steering Committee (Brief Summary)
Update on Ecological Mapping Project
Summary of Existing IRS Projects
Update on Current Funding and Projections for FY 94 Funding
New Projects
Pathfinder Project - Overview

April 14 Wednesday

This morning is left largely unstructured to allow time for ad hoc meetings, informal discussions, focus group meetings, idea sharing, and review of the posters. If you would like to announce a meeting, see a workshop organizer.

AM - 8:00 - noon

Poster displays on processes, informal group discussions on processes and strategic planning.
Crescent Ballroom A

8:30 - 9:30

Concurrent with poster session - Discussion on process for revising, matching and describing Ecosubregion Maps. Meeting Room I

10:00 - 10:15

Coffee break

9:30 - 11:30

Concurrent with poster session - Discussion on Ecological Classification and the needs for national standards. Meeting Room IV

11:30 - 1:00

Lunch

PM - 1:00 - 1:15

Issue Paper 2 - Strategic Planning, Organization, and Budget - Doug MacCleery - Crescent Ballroom A

1:15 - 2:30

Issue 2: Planning, Organizing, and budgeting for integrated inventory, classification and mapping.

Mini-Groups for Issue 2:

A. Recommend a strategic planning process for integrated inventory, classification and mapping, including timeline for implementation.

B. Identify barriers to integration and suggest how they can best be removed.

C. Recommend organizational and budgetary structures for achieving the needed coordination and integration of inventories, classification and mapping for all levels of the organization.

2:30 - 3:00

Break

3:00 - 4:00

Facilitated combined topic groups. Purpose will be to develop a combined recommendation from the mini-groups working on issue 2.

Group A Crescent Ballroom A

Group B Meeting Room I

Group C Meeting Room IV

4:00 - 5:00

Combined work group reports and facilitated discussion - Rob Mrowka - Crescent Ballroom A

April 15 Thursday

AM	8:00 - 8:30	Issue Paper 3 - Uniform processes for ecological classification and resource mapping and inventories - Gyde Lund and Warren Harper - Crescent Ballroom A
	8:30 - 11:30	Mini-Groups for Issue 3: A. Specify a nation-wide design and structure for our mapping, inventory, and classification programs to reflect the needs of ecosystem management and that goes beyond existing direction and that will provide continuity across regions and stations. B. Specify how the aquatic classification and inventory can be integrated with the national hierarchical framework. C. Define how ecological land units are to be used to link to existing vegetation and other inventories and to information for forest and national planning and reporting.
	11:30 - 1:00	Lunch
PM	1:00 - 3:00	Facilitated combined topic groups. Purpose will be to develop a combined recommendation from the mini-groups working on issue 3. Group A Crescent Ballroom A Group B Meeting Room I Group C Meeting Room IV
	3:00 - 3:15	Break
	3:15 - 4:45	Work group reports and facilitated discussion. Moderator - Tom King - Crescent Ballroom A
	4:45 - 5:00	Wrap up - Avers

April 16 Friday

AM	8:00 - 10:00	ECOMAP Meeting - What next? Crescent Ballroom A. Open to All.
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LISTING OF PARTICIPANTS

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Research Deputy Area, Jerry SESCO
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NATIONAL HIERARCHICAL FRAMEWORK
OF ECOLOGICAL UNITS
FOR ECOSYSTEM CLASSIFICATION
(Draft 5/26/93)

Summary

The proposed national hierarchical framework is a systematic method for stratifying the earth into progressively smaller spatial units of increasingly uniform ecological potentials. Ecological units are based on components that either control or modify the inputs of solar energy, precipitation, and nutrients. Ecological types are classified and ecological units are mapped at different spatial scales based on combinations of physical and biological factors.

Ecological classification and management requires information on the stable (mostly physical), transient (mostly biological), and human dimensions. The stable dimension is represented by the ecological units which integrate climate, geology, and topography to varying degrees depending on level of the hierarchy. The transient dimension includes inventories of existing vegetation, wildlife, fish, water quality, and other resources that change periodically. The human dimension includes social and economic inventories. All three dimensions need to be integrated for comprehensive ecosystem classification and analysis.

The national framework is based on published information and covers a range of geographic scales, from very broad regions down to small sites. The categories of the hierarchy are not inclusive, but consist of those commonly available and referred to in the literature. It consists of four national levels that will be used for a range of planning, reporting, monitoring, management, and conservation purposes:

PURPOSE AND USE OF HIERARCHY AT EACH LEVEL	NATIONAL LEVELS OF HIERARCHY	ECOSYSTEM AND ECOLOGICAL UNIT SCALE
Broad Analysis and modeling	Ecoregion	>1000s of square miles
RPA Assessment, State planning	Subregion	100s to 1000s square miles
National Forest planning	Landscape	10s to 1000s of acres
Project planning	Land units	1 to 10s of acres

Each national level in the hierarchy is subdivided into two or more reference levels to provide flexibility for a range of purposes and uses.

Development of the hierarchy follows a dual top down and bottom up approach, where broad scale variations in climate, geology and topography, and fine scale variations in biota and soils are examined simultaneously. Ecoregion maps are developed by stratification at the same time as field classifications and inventories are being done for ecological types and units. Many single component maps are available, including climate, geology, soils, water, and vegetation, and will be used at all levels of the hierarchy. Data bases and analysis techniques are being developed to provide interpretation of the ecological units.

The hierarchical framework is largely a Forest Service effort, although there has been involvement by the Soil Conservation Service, the Bureau of Land Management, the Nature Conservancy, the Fish and Wildlife Service, the U.S. Geological Survey, and others at national and regional levels. The Forest Service now needs to increase participation of other groups to develop an ecological classification system based on the best available scientific principles and knowledge. Our goal is to develop an ecological classification and inventory system that is applicable nationwide, for all Forest Service lands and to provide a prototype system acceptable to all agencies.

The current framework as described in this paper is tentative; criteria, and concepts continue to evolve. Comments and suggestions for revisions are welcome and should be sent to USDA Forest Service, 201 14th Street, S.W., Washington, D.C. 20250, ATTN: Mr. Peter E. Avers, Watershed and Air Management Staff.

Introduction

Land managers have long realized that individual resources are actually interdependent parts of more complex systems, but until recently there has been little impetus to change methods of resource management. The traditional approach of the Forest Service to resource planning, and methods of assessing indirect and cumulative effects may have been adequate to answer the old questions, but new questions are being asked today. We need to expand the scope of our analysis to accommodate the effects of scale on ecosystems to adequately respond to contemporary and emerging issues. Accordingly, Chief F. Dale Robertson has directed the Forest Service to "Integrate thinking and actions at multiple spatial and temporal scales . . ." as part of ecosystem management.

The two primary objectives for the National Hierarchical Framework of Ecological Units are: (1) to provide a uniform ecosystem framework for use in land and resource management analysis and planning; and (2) to develop an ecologically based information system to aid in evaluating land and water capability, interpreting ecological relationships, and assessing effects of management (Avers and Schlatterer, 1991).

We need working definitions and ecologically based inventories to implement ecosystem management. We also need to understand ecological patterns and processes, and inter-relationships between social, physical, and biological systems. This will require better information on: (1) the spatial distribution of plants, animals and environments; and (2) the nature of ecological processes, including the demographics of species; development and succession of communities; and effects of human activities and land use on species and ecosystems (Urban et al. 1987). Research has a critical role in obtaining the foregoing information.

The hierarchical framework for ecologic unit design provides a basis for identifying the spatial distribution of biophysically significant environments at different geographic scales. Ecological units delimit areas of different biological and physical potentials that, ideally, define the limits or range of existing and future conditions. Ecological unit inventories can be coupled with inventories of existing vegetation, wildlife, and human elements to characterize complexes of life and environment, or ecosystems. These

integrated inventories can be combined with our knowledge of process to facilitate a more ecological approach to resource planning, management, and research.

The ecological classification and management process can be visualized as the integration of three equally important components, or dimensions: (1) stable resources (mostly physical), (2) transient resources (mostly biological), and (3) human elements (mostly social and economic), as illustrated in Figure 1.

Stable Resources -----	+	Transient Resources -----	+	Human Elements -----	=	Ecosystem Classification -----
Ecological Units	+	Existing Vegetation Wildlife & Fish	+	Social Economic Cultural	=	Ecosystem Management
-Terrestrial -Aquatic		-Populations -Distributions		-Historical -Present		

Figure 1. The triple dimension of ecosystem classification and management.

To achieve this requires an overlay system that allows spatial comparison and evaluation of appropriate data from each dimension. The stable dimension includes the relatively unchanging part of the environment such as climate, landform, geology, soils, watershed boundaries, and the occurrence of lakes, rivers, and streams. The Transient dimension includes classification and inventories of biological and physical components that are affected by management activities, ecological processes and basic land capability. Primary examples are fish and wildlife populations, water quality, and existing vegetation. The human dimension adds a wide array of social and economic elements related to values, markets, infrastructure, cultural resources, and political realities that affect planning and management of ecosystems. This triple dimension concept of ecosystem classification and management is applicable at each level in the hierarchy.

It is recognized that the exact boundaries for each level envisioned in this process and developed in map format may not fit every analysis and management need. Developing boundaries of areas to analyze issues, however will not change the boundaries of ecological units. In some cases, the ecological unit may be the analysis area. In other cases, watersheds, existing conditions, management emphasis, proximity to special features (e.g., research natural, wilderness, or urban areas) or other conditions may define an analysis area. In these cases, ecological units can be aggregated if needed to address relevant issues and concerns.

This paper presents a brief background on regional classifications, underlying principles and a hierarchical framework for Ecological Unit Design. The framework is needed to improve national, regional, and forest level planning; to standardize approaches to ecosystem management across national forests and regions; and to facilitate interagency data sharing and planning efforts.

Background - Regional Land Classifications

Regionalizations have been proposed for classification purposes using single and multiple ecological factors. A number of these have been reviewed while formulating the national hierarchy. Of the single component systems, physiographic provinces delineated by Fenneman (1938) are wellknown and are based on relief, stratigraphy, lithology, and other geologic factors. Potential natural vegetation (Kuchler 1964) and forest cover types (Eyre 1980) have been suggested as methods of subdividing the United States into zones that represent relatively homogeneous environmental conditions. Climate has also been used in single component regionalizations (Baldwin 1973).

Numerous multiple component hierarchies have been advocated nationally and internationally. The Soil Conservation Service (U.S. Department of Agriculture 1981) uses major land resource areas (MLRA) that are characterized by similar patterns of soil, land use, climate, and water resources. MLRAs, however, are weighted towards soil components and land use patterns.

Omernik (1987) and Gallant and others (1989) developed a comprehensive national regionalization mainly for use in classifying streams for water resource management. Geographical units were based on four biophysical components: soil, landform, vegetation and a cultural factor - current land use. Climatic data, consisting mainly of precipitation, was indirectly included in the regionalization through land use patterns. This approach has an ecological basis, but land units integrate many components into a regionalization consisting of two levels. Heavy reliance on patterns of land use may adequately integrate climatic conditions and soil properties needed to address water related questions, but is tenuous for broader purposes of forest ecosystem classification.

Other classifications evaluated included a method of land stratification by Wertz and Arnold (1972), a component classification framework (Driscoll and others 1984, Corliss 1974), several Canadian systems (Hills 1952, Jones and others 1983), and a system used in German the State of Baden-Wurttemberg as described by Barnes (1984).

Each of these systems have strong points that the proposed hierarchy builds upon. The concepts and terminology of the national system draws upon the strengths of former work, seeking to achieve consistency in their application throughout the United States. The proposed classification and mapping system relies upon multiple ecological factors at all scales to strengthen the system's ecological basis.

Underlying Principles

Ecosystem concept. Ecosystems are places where life and environment interact; they are three dimensional segments of the earth (Rowe 1980). Ecosystems exist at all spatial scales, from the global ecosphere down to specific sites, and are defined by associations of ecological factors (climate, gross physiography, landform, soil, water, plants, and animals; FSM 2060).

While the association of factors is all important in understanding ecosystems, factors are not equally important in defining ecosystems at all spatial scales (Bailey 1985). Macroclimate limits the absolute amount of energy and moisture that can reach the earth's surface, and dominates ecosystem patterns and processes at all spatial scales (Bailey 1987, Denton and Barnes 1988). Within

climatic regions, gross physiography transforms macroclimate. Within climatic-gross physiographic regions, landform variations further modify macroclimate (Rowe 1984, Smalley 1986, Bailey 1988B, affect the dispersal of organisms, and influence the frequency and spatial pattern of disturbance by fire and wind (Swanson et al. 1988). Within climatic-gross physiographic-landform regions, water, plants, animals, soils, and topography interact within the context of higher level constraints to form ecosystems at the site level (Major 1969). The challenge of ecological classification and inventory is to distinguish associations of ecological factors at different spatial scales, and to define ecological units that reflect these different levels of organization.

Spatial hierarchies. Ecosystems can be conceptualized as occurring in a nested geographic arrangement, with smaller ecosystems contained within larger ones (Allen and Starr 1982, O'Neill et al. 1986). The hierarchy of these systems is organized in decreasing orders of scale by the dominant ecological factors affecting biophysical systems. Processes and resulting patterns at any given scale operate within the context of higher levels of a spatial hierarchy. Broader-scale influences affect embedded ecosystems, and properties of smaller ecosystems emerge in the context of surrounding, larger systems. Given this, ecological units need to be defined at different hierarchical levels that correspond with the spatial variability of dominant ecological factors at their respective scales of influence.

Life and environmental interactions. Life and environment have interacted and co-developed at all spatial and temporal scales, one modifying the other through feedback. At a global scale, first it was the evolution of cyanobacteria, then terrestrial plants capable of photosynthesis, carbon fixation and oxygen production that converted the earth's atmosphere from a hydrogen to an oxygen base and sustain it today. It was the migration of species in response to climate change, and the interaction of their environmental tolerances and dispersal mechanisms with landform controlled migration routes that formed today's global and continental patterns in species' distributions.

Landscapes have also been affected by biotic-environmental interactions. Some forest communities are adapted to, and in cases dependent on, periodic fires. These communities tend to occupy droughty soils in fire-prone landscape positions, produce volatile foliar substances, and accumulate litter, thereby increasing their susceptibility to burning. In contrast, fire-resistant communities tend to occupy moister soils in more protected landscape positions, and produce litter that decomposes rapidly, thereby decreasing their susceptibility to burning. In these cases, life and environment have interacted within the constraints of macroclimate and landform to affect natural fire regimes, and hence landscape patterns and processes.

Sites have also been affected by biotic-environmental interactions. For example, vegetation often induces soil development over time through carbon and nutrient cycling. If soils aggrade sufficiently, vegetation may undergo succession to communities with higher fertility requirements. In a point in time, the temperature, moisture and light tolerances of individual plant species interact with site specific soil and vegetative conditions (eg. soil moisture, canopy closure, plant competition) to determine the vegetative

composition and structure of local ecosystems. Once again, life and environment have interacted to form site level patterns and processes.

Integrating inventories. To map ecosystems, or places where life and environment interact, requires the integration of physical, biological and human dimension inventories. These inventories provide data and information on existing conditions that change readily through time, and on potential conditions that are relatively stable. Existing conditions are mapped as vegetation, wildlife, water quality, and so forth. Potential conditions are mapped as ecological units. Biotic distributions and ecological processes can be evaluated in the context of these integrated inventories.

To manage ecosystems, we need a basic understanding of how processes will change existing conditions. Change will occur within a range of possibilities set by ecological potentials. Management for a species that is obligate upon a specific habitat for example, depends upon the potential of an area to support that habitat, as well as the presence or immigration of the species. Initial conditions change due to particular processes, and these processes operate within the constraints of biotic and environmental potentials.

Ecosystem managers need a means of integrating separate themes of existing and potential conditions to delineate ecosystems, then, as well as an understanding of processes to manage these ecosystems. GIS and developing technologies will provide tools to facilitate integration.

Fundamental base maps are key to using integrated resource inventories. The first set of maps that provide the basic foundation includes the primary base map series showing topography, streams, lakes, ownership, political boundaries, cultural features, and other layers in the Cartographic Features File. On this base, next logical layers include watersheds and ecological units at appropriate spatial scales. Next would be layers of information on existing vegetation, wildlife populations, fish distribution, demographics, cultural resources, economic data and other information needed from the stable, transient and human dimensions to delineate ecosystems to meet planning and analysis needs.

Spatial and temporal variability. The structure and function of ecosystems change through space and through time. The many different states of life and environment that we observe at any given time are spatial sources of variability. The changes in these conditions that we observe through time are temporal sources of variability. Temporal and spatial sources of variability need to be partitioned in order to effectively evaluate, map or manage ecosystems.

Within a landscape, particular locations may be wetter or drier, or more or less fertile than other locations due to differences in soil properties or hydrology. Each of these conditions favor certain plants and animals. In the midwest this environmental-biotic gradient could include oak savannas, xeric jack pine, dry-mesic pine-oak, mesic northern hardwood, and hydric hardwood or conifer communities. These changes represent spatial sources of variability affecting local ecosystem structure and function.

At broader spatial scales, across a region for example, environmental conditions may vary from colder to warmer due to changes in macro-climate. In

the northern hemisphere, communities found in equivalent moisture-nutrient conditions in cooler northern latitudes are replaced in lower latitudes by southern counterparts. These changes at macro-scales represent spatial sources of variability affecting regional, landscape, and local ecosystem structure, and function.

Changes also occur through time. At temporal scales measured in years, a given ecosystem may be young, mature, over-mature or old growth. Each of these temporal conditions benefit certain plant and animal species and assemblages. Old-growth forests provide for species such as the spotted owl and pileated woodpecker. Mature forests with substantial amounts of coarse woody debris benefit tree species that establish on rotting logs, such as eastern and western hemlock. Young, regenerating forests favor shade intolerant vegetation and animal species such as white tailed deer and ruffed grouse. These changes at finer time scales represent temporal sources of variability of local ecosystem structure and function.

At temporal scales measured in centuries, local ecosystems undergo change such as succession. The successional status of ecosystems affects structural and functional attributes including food webs, total biomass, ratios of net primary production to respiration, nutrient and carbon cycling, and so forth. From a landscape perspective, these successional changes form a shifting mosaic of local ecosystems. These changes at broader time scales represent temporal sources of variability affecting landscape and local ecosystem structure and function.

To define ecological types and units at lower tiers of the hierarchy, specialists filter spatial sources of variability from temporal sources by examining relationships of life and environment within a particular time reference. Often times, relationships are observed in mature, climax or late successional ecosystems, with followup studies conducted to evaluate structural and functional changes due to time.

Spatial and temporal variations should be examined in the context of one another. Spatial states (conditions of life and environment) affect the nature of ecological processes, and an understanding of processes provides information useful in defining class limits of ecological types and units. As we grow to understand certain processes, those that sustain the productivity or diversity of particular ecosystems for example, we'll need a means to extrapolate findings to similar spatial settings to effectively sustain other ecosystems. When combined with information on existing conditions, the national hierarchy of ecological units will provide a framework for studying spatial and temporal variations of ecosystems for ecosystem management.

Ecological Unit Design

The primary purpose of ecological units is to delineate land and water areas at different levels of resolution that exhibit similar patterns in: (1) potential vegetation, (2) soils, (3) hydrologic function, (4) landform, (5) lithology, (6) climate, and (7) natural processes for cycling plant biomass and nutrients (e.g. succession, productivity, fire regimes). These units are designed at various scales for different resource management and planning needs (Tables 1 and 2).

Table 1

NATIONAL HIERARCHY OF ECOLOGICAL UNITS
FOR ECOSYSTEM CLASSIFICATION
USDA, Forest Service
5/25/93

*** REVIEW DRAFT ***

*** REVIEW DRAFT ***

PURPOSE, USE	NATIONAL LEVELS	MAP/POLYGON SCALE RANGE	LSI* REFERENCE LEVELS	CLIMATE	GEOLOGY & TOPOGRAPHY	SOIL	VEGETATION POTENTIAL NAT. COMMUNITY	HYDROLOGY	DELINEATION EXAMPLE
RPA planning.		1:30,000,000 to	Domain	Evapo- transpiration climatic zones & types	Latitude & Continental landmasses	Broad areas of similar climatic influence on soil formation	Broad areas of similar climatic influence on vegetative life form	Broad areas of similar climatic influence on hydrologic function	Moderate Continental Mixed Forest Province
Broad applicability for modelling and sampling (e.g., global change)	Ecoregion	1:3,500,000 ----- 100,000's to 1,000's of sq. miles	Division (Ecological) Province						
Multi-forest, statewide & multi-agency analysis	Subregion	1:3,500,000 to 1:250,000 ----- 1,000's to 10's of sq. miles	Section Subsection	precipitation & temperature	Geomorphic province Geologic age/origin ----- Elevation zones	Phases of orders, sub- orders or great groups	Formation or series	Geomorphic province/ process	Southern Superior Uplands Section
Forest Planning	Landscape	1:250,000 to 1:24,000 ----- 10,000's to 100's of acres	Landtype Association Landtype	precipitation & temperature	Geomorphic process Stratigraphy (Geologic formation) ----- Landform	Phases of subgroups, families, or series	Series, subseries, or plant associations	Drainage density & in- ternal relief or valley bottom type (width,slope) Lake type	Drumloid Ground moraine Loamy Acer & Tsuga Series LTA
Project Planning	Land Unit	1:24,000 and larger ----- Less than 100 acres	Landtype Phase Site	soil temperature & moisture	Lithology (rock type) Geomorphic process ----- Position (elev/slope aspect)	Phases of families or series	Plant associations or phases	Stream type (width:depth, sinuosity, gradient); Chan- nel Unit(pool, riffle, glide) Lake subtype	Champion fine sandy loam Moderately wet Nearly level & undulating LTP

* LSI=Land System Inventory. Terms are derived from Bailey's Ecoregions, 1983 (Domain, Division, Province, Section) and Wertz and Arnold, 1972 (Planet, Continent, Physiographic Province, Section (or Subprovince), Subsection, Landtype Association, Landtype, Landtype Phase, and Site

Table 2

ABBREVIATED DESCRIPTION OF WORK ACTIVITIES, INFORMATION SOURCES,
AND CRITERIA FOR ECOLOGICAL MAP UNIT DEVELOPMENT

GENERAL LEVEL	WORK ACTIVITIES	SOURCES OF INFORMATION	PRIMARY DESIGN CRITERIA
Ecoregions	Minor revisions of Balley's maps (1980), as appropriate to regional analysis needs.	Existing ecoregion maps	Climatic zone, group & type (Koppen, 1931) Gross Physiography.
Subregions	Assimilation and integration of existing information. Coordination of map unit design between Forest Service Regions. Involve appropriate USFWS-GAP and EPA-EMAP, SCS, BLM, TNC, USGS, NPS	Physiographic maps, state geology maps, SCS--land resource regions and MLRA's potential vegetation maps (series and formation), AVHRR spectral data, SCS-STATSGO maps.	Regional Climate. Geomorphic process, geologic age/origin. Physiography. Vegetation formation.
Landscapes	Field mapping or aggregation of detailed mapping information. Coordination of map unit design between National Forests.	Geology and topographic maps, soil resource inventories, plant association maps, special data	Geomorphic Process Geologic formation. Relief and land surface form. Veg series,subseries.
Land Units	Field mapping and plot level sampling. Coordination of map unit design between Forest Service Districts. Development of appropriate classifications (e.g., stream types, plant associations, ecological site).	Plot level data, detailed soil maps, topographic maps (DEM data)	Landform, plant association, soil family & series. Rock type. Local topography.

In the proposed national hierarchy, ecoregions differentiate broad scale environments used in national planning efforts. Ecological units are further delineated at Subregion, landscape, and land unit levels for regional, national forest and project planning efforts, respectively.

Ecological units are differentiated and described by multiple components including climate, physiography, landform, soils, water and potential vegetation (FSH 2060, 2090, Table 1). These components may be described individually and then combined, or by simultaneously evaluating a combination of components in ecological unit design (FSH 2090). The first option may be increasingly utilized as geographic information systems become more available. The interrelationships among independently defined components, however, will need to be carefully evaluated to identify units that are both ecologically significant and meaningful to management. The benefits of having various disciplines cooperate in devising integrated ecological units include the development of interpretations (Avers and Schlatterer, 1991). Advantages and disadvantages of these two approaches are reviewed by Zonneveld (1989) and Bailey (1988a).

Historical human uses of the land are also used as map unit design criteria when past use has substantially altered land capability or interpretations of ecological units. Severe erosion and sedimentation from past farming, disturbed land from mining, and areas that were repeatedly harvested, or burned are examples.

It should be noted that land classification systems are devised by humans to meet human needs. Ecosystems and their various components often change gradually, forming continuums on the earth's surface that cross administrative and political boundaries. Based on their understanding, humans decide on ecosystem boundaries using physical, biological, and social considerations.

All ecological units are recognized by differences in climatic regime. Ecoregions (domains, divisions, and provinces) are areas of increasingly homogeneous macroclimate. Topographic relief and gross physiography transform climatic inputs, and hence are important criterion for recognizing Subregions (sections and subsections). Elevation, landform, and geology further alter macroclimate, and are used in differentiating landscape and land unit levels. Determining boundary criteria by climate as modified by landscape components provides a logical basis for delineating large and small ecological units. The method for ecological unit design requires (1) establishment of macroclimatic regions having similar local climatic conditions on similar landscapes, and (2) determination of the variations in the landscape components that affect energy, moisture, and nutrient gradients.

The importance of different ecosystem components in ecological unit design vary according to mapping area and scale. A challenge in mapping is to identify primary "driving" variables that can be delineated and are highly associated with other variables of interest. These primary variables comprise the differentiating criteria used in map unit design. The differentiating criteria used for coarse scale ecoregion maps include climatic zones and gross physiography, that are defined in conjunction with broad water and landform groups as expressed by potential natural vegetation (Table 1). Detailed land and water unit maps utilize topography (e.g., elevation, slope, aspect, and

position), potential natural vegetation (associations), soil types, and channel morphology as differentiating criteria.

Classification Framework

The National Ecological Unit hierarchy presented in Tables 1 and 2 may be further subdivided as shown by the reference levels for planning or analysis needs. The terminology utilized in naming Ecological Unit levels follow Ecoregion (Bailey 1983) and Land Systems Inventory (Wertz and Arnold 1972, USDA Forest Service 1976). The hierarchy is based on concepts developed by numerous scientists and resource managers (Allen and Starr 1982, Bailey 1987, Barnes et al. 1982, Wertz and Arnold, 1972, Cleland et al. 1992, Jordan 1982, Major 1969, McNab 1987, Meentemeyer and Box 1987, Platts 1980, Rowe 1980, Russell and Jordan 1991). The hierarchical framework also provides the basis of a system of classifying wetlands and deep-water habitats (Cowardin and others 1979).

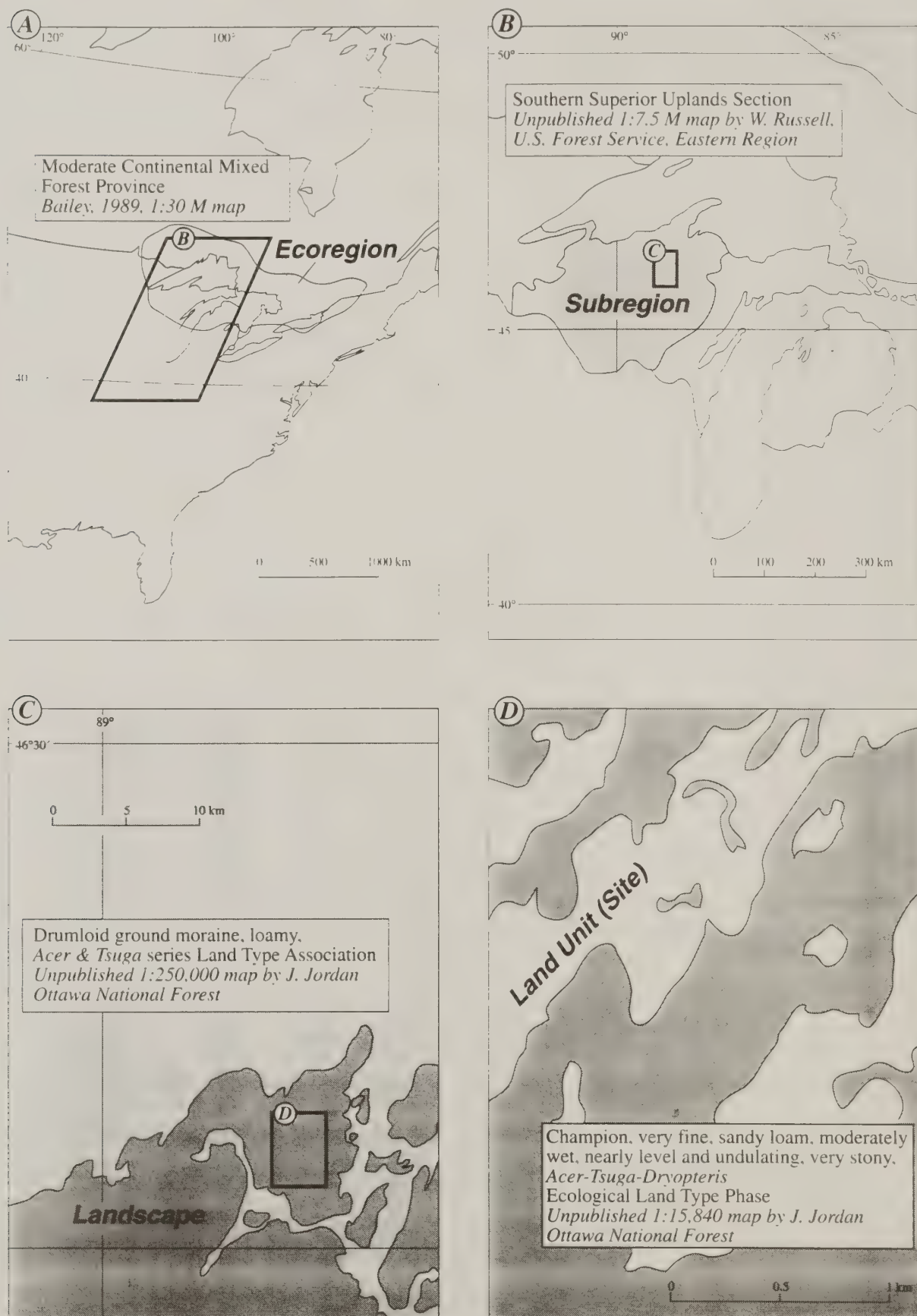
The following presents an overview of the differentiating criteria commonly used in the development of the general and expanded reference levels of the national framework. Figure 2 depicts generalized maps at each national level of the Hierarchy.

A. Ecoregions - At this scale, ecosystems are recognized by differences in global and continental climatic regime and gross physiography. The basic assumption is that climate governs energy and moisture gradients, thereby acting as the primary control over more localized ecosystems. Gross physiography (with its geologic substrate, its surface shape or relief) modifies climatic regime. This modification occurs according to the distribution and location of landmasses in relation to latitude, proximity to major bodies of water, and the influence of major land masses such as mountain ranges. Ecoregions have been mapped and described for the United States (Bailey 1976, 1980), North America (Bailey and Cushwa 1981), and the Continents (Bailey 1989). Three levels of ecoregions can be identified:

1. Domains - subcontinental divisions of broad climatic similarity, such as polar or tropical, that are affected by latitude and global atmospheric conditions. Climate of the polar domain is controlled by arctic air masses, which creates cold, dry environments where summers are short. In contrast, the climate of the tropical domain is influenced by equatorial air masses and there is no winter season. Domains are also characterized by broad differences in annual precipitation, evapotranspiration, potential natural vegetation and biologically significant drainage systems. The dry domain, for example, comprises the arid and semi-arid regions of middle and adjacent latitudes; has discontinuous vegetation of steppe, xerophytic bush, and desert types; with hydrologic function limited to only intermittent and local runoff. The four Domains are named according to the principal climatic descriptive feature of each: polar, dry, humid temperate, and humid tropical.

2. Divisions - subdivision of a Domain determined by isolating areas of definite vegetational affinities (prairie or forest) that fall within the same regional climate, generally at the level of the basic types of Koppen (1931). Divisions are delineated according to: (a) the amount of water deficit (which subdivides the dry domain into semi-arid, steppe or arid desert, and (b) the winter temperatures, which have an important influence

Figure 2. Hierarchy of ecological units at a range of scales. NOTE: You can receive copies of this map (mailed or faxed) per your request to S.DAVIS:W01A. Please include your fax number or complete mailing address.



on biological and physical processes and the duration of any snow-cover. This temperature factor is the basis of distinction between temperate and tropical/subtropical dry regions. Divisions are named for the main climatic regions they delineate, for example Steppe, Savannah, Desert, Mediterranean, Marine, and Tundra. Examples of characteristic vegetation types associated with divisions include the boreal forest and taiga of the sub-arctic climatic zone, grasslands of the prairies, and broadleaf evergreens of the rainforest.

3. Provinces - subdivision of a division that correspond to broad vegetation regions, which conform to climatic subzones controlled primarily by continental weather patterns. Provinces are also characterized by the same type of zonal soil. Within the steppe zone, for example, a semiarid steppe (short-grass prairie) climate that has a dry summer season and occasional drought can be distinguished from an arid semiarid (sagebrush) climate that has a very pronounced drought season plus a short humid season. These climatic subzones are evident as extensive areas of similar dominant climax or late-successional vegetation growing on well drained soils in landscapes of moderate relief. The climax vegetation corresponds to the major plant formation (e.g., deciduous forest) characterized by uniformity both in physiognomy and in the structure of the climax type. Each climatic subzone comprises both the climax formation and all the successional stages within its geographic range. Provinces are typically named using a binomial system consisting of a geographic location and vegetative type. Bering Tundra, California Dry Steppe, and Eastern Broadleaf Forests are examples of province-level ecological unit delineations.

Highland areas exhibiting altitudinal vegetational zonation and having climatic regime (seasonality of energy and moisture) of adjacent lowlands are classified as provinces. The climatic regime of the surrounding lowlands can be used to infer the climate of the highlands. For example, in the Mediterranean Division along the Pacific Coast, the seasonal pattern of precipitation is the same for the lowlands and highlands except that the mountains receive about twice the quantity. These provinces are named for the lower-elevation and upper-elevation (subnival) belts, e.g., Rocky Mountain Forest-Alpine Meadows.

B. Subregions - The modification of regional climate by geologic factors and landform is emphasized at this level. Major geologic stratigraphic units are system and series. These factors influence moisture availability and exposure to radiant solar energy, which in turn directly control hydrologic function, soil-forming processes, and potential plant community distributions. Landforms and water at this level have relatively similar physical characteristics (e.g., surface shape, relief) and geologic history (e.g., origin, age, geomorphic process). Maintenance of air quality standards pertaining to national forests are typically addressed at this level in the hierarchy.

1. Section - Broad areas of similar geomorphic process, geologic origin, drainage networks, and landforms that influence precipitation patterns and temperature regimes. Such areas are often inferred by relating geologic maps to potential natural vegetation "series" groupings as mapped by Kuchler (1964). Boundaries of some sections approximate geomorphic provinces (for example Blue Ridge) as recognized by

geologists. Section names generally describe the predominate physiographic feature upon which the ecological unit delineation is based, for example, Flint Hills, Great Lakes Morainal, Bluegrass Hills, Appalachian Piedmont.

2. Subsection - Smaller areas of sections with similar geology (lithology and structure), landform, primary geomorphic process, and valley section types. Macroclimate is modified in localized areas of differing precipitation and temperature regimes. For example, solar radiation on exposed rock formations can alter local temperature regimes through creation of thermal updrafts, which in turn induce thunderstorms and channel wind currents. Names of subsections are usually derived from geologic features, such as Plainfield Sand Dune, Tipton Till Plain, and Granite Hills.

C. Landscapes - At the landscape scale, ecosystem patterns and processes are controlled primarily by landforms based upon geologic lithology and stratigraphy, geomorphic history, and land surface form. These factors influence soil and potential natural vegetation distributions, hydrologic function, and natural disturbance regimes. Local landform patterns become apparent at this level in the hierarchy, and differences among units are usually obvious to on-the-ground observers. At this level, terrestrial features and processes have a strong influence on ecological characteristics of aquatic habitats (Platts 1979, Ebert et al. 1991).

1. Landtype Association - Subdivisions of landscapes or groupings of landtypes based upon similarities in geologic rock types, soil complexes, stream types, lakes, riparian areas, wetlands, valley sections and potential natural vegetation. Microclimate may be modified by features such as large concave/convex land-shapes and altitudinal zones in mountainous areas. In mountainous terrain, wind patterns may be modified by ridge and valley sequences which in turn influence evapotranspiration, soil temperature, and moisture regimes. Repeatable patterns of soil features and plant communities are used in delineating land units at this level.
2. Landtypes - Subdivisions of landtype associations or groupings of landtype phases based on similarities in lithology, stratigraphy, geomorphic process, land surface form, stream types, stream reaches, lakes, patterns of soil families or series, and plant associations. Land surface form that influences hydrologic function (e.g., drainage density, dissection relief) is often used to delineate different landtypes in mountainous terrain. Valley bottom characteristics (e.g., confinement) are commonly utilized in establishment of riparian landtype map units.

D. Land Units - At the basic land unit scale, ecosystem patterns, and processes are controlled primarily by interactions of local topography, water, soils and vegetation. These factors influence the structure and composition of plant communities, as well as hydrologic function (wetland, lake) and channel types.

1. Landtype Phase - Subdivisions of landtypes based on topographic criteria (e.g., slope-shape, steepness, aspect, position), channel

morphology, land and pond trophic states, associations and consociations of soil taxa and plant associations. These factors influence or reflect the microclimate and fertility of a site. Landtype phases are established based on interrelationships between soil characteristics and potential natural vegetation. In riparian mapping, landtype phases may be established to delineate different stream type environments (Herrington and Dunham 1962).

2. Sites - The site is the basic sampling unit used in developing ecological classifications (Jensen et. al. 1991) and is not a classification unit. Land units at the site level are generally too small to be inventoried operationally. A water unit, for example, could be an individual pool or riffle.

Use of Ecological Units

The classification and inventory of ecological units provides basic information for natural resource planning and management. When combined with information on existing conditions and process, ecological units may be used in resource assessments, environmental analyses, establishing desired future conditions, and for managing and monitoring natural resources.

Resource assessments. The hierarchical framework for designing ecological units will be useful in conducting multi-scaled assessments of resource conditions. Broadly defined ecological units (ecoregions) can be used to assess potential habitat conditions for animal species with large home ranges (e.g., neo-tropical birds). Intermediate scale units (e.g., Landtype Associations) can be used to identify areas with similar natural disturbance regimes (e.g., mass wasting, flooding, fire potential). Narrowly defined land units can be used to assess site level conditions including distributions of terrestrial and aquatic biota; forest growth, succession, and health; and various physical conditions (e.g., soil compaction and erosion potential (water quality, timing and quality). Information can be aggregated for some types of resource assessments. Resource production capability, for example, can be estimated based on potentials measured for landtype phases, and estimates aggregated to assess ranger district, national forest, regional, and national capabilities.

Data bases and analysis packages. Ecological data bases and analysis packages are being developed for characterizing ecological units and to provide management interpretations and capability ratings. Systems like Ecodata and Ecopac by Keane et. al. (1990) provide the basic structure for management and analysis.

Environmental analyses. Ecological units delineate land areas based on biophysical potentials, and when combined with information on existing conditions provide a means of analyzing the feasibility and effects of management alternatives. The hierarchical organization enables the assessment of indirect effects as well, and provides a basis for analyzing an ecosystem in terms of its condition and its setting. A sedge meadow within a forest, for example, functions differently than one within a prairie (Bailey, 1985). A woodlot within an agricultural matrix functions differently than one within a forested matrix. These differences are detected by examining the system at

several spatial scales; by looking at conditions and processes within and outside the ecosystem.

The ecological unit hierarchy facilitates analysis of various issues at relevant scales. In assessing population viabilities of mobile species like bears or wolves, for example, conditions at the both the landscape and site level are important. Across the landscape, there may be reproducing populations in high quality habitats; these are source populations. In other locations, there may be less suited habitats where mortality exceeds reproduction. In the latter case, populations are dependent upon immigration from source populations to maintain existing numbers.

Within a landscape, the quality of local habitats depends on a number of factors including ecosystem diversity, vegetation composition, and structure, and land-use (eg. road densities, fragmentation). Ecological units can be used to assess ecosystem diversity and vegetation potentials (eg. seasonal forage), as well as identifying potentials to manipulate vegetation for habitat improvement. Multi-scaled analyses can detect these types of landscape and local ecosystem relationships. In this example, population viabilities can be analyzed at both landscape and land unit levels, and marginal habitats can be expanded, linked or otherwise improved using information on existing conditions and ecological unit potentials.

Natural variability and management effects. Ecological units differ in vegetation composition, animal distributions, hydrologic function, and so forth due to changes in ecosystem form and process, and management induced disturbance. To understand management effects, natural processes must be differentiated from those induced by humans (Jensen et al. 1991). To measure changes due to management, we need baseline information on natural conditions and processes that change at different scales. For example, the natural erosion rates of watershed hillslopes influence the sediment loadings in smaller sized riparian habitats. The background effects of the larger system need to be considered while analyzing management alternatives at the local scale.

Management activities take place within one or more local ecosystems, and it is at this scale that direct effects are assessed. The indirect and cumulative effects of management, however, take place at different points in space or time, often at higher spatial scales. Ecological units defined at different hierarchical levels will be useful in conducting multi-scaled analyses for managing ecosystems and documenting environmental effects.

Forest land and resource management planning. ¹The National Forest Management Act established the requirement for land and resource management planning for each unit in the National Forest System. These forest plans provide the strategic framework for our management activities on-the-ground.

¹SEVEN KEY MESSAGES ABOUT FOREST PLANNING, Joan M. Comanor, Director - Land Management Planning, USDA Forest Service, Washington, D. C., A Presentation at the National Workshop on Taking An Ecological Approach to Management, Salt Lake City, Utah April 27, 1992

They are the mechanism for integrating national and regional policy direction, such as the RPA Program Policy or taking more of an ecological approach, with local capability, suitability, and opportunity in an applied and meaningful way on each national forest or grassland. Thus, they are the "gate" for examining national and regional issues, priorities and policies in a local context and developing a strategy to respond that is locally relevant.

The forest plan gateway culminates in six key management decisions: goals and objectives, management areas and their prescriptions, standards, guidelines, monitoring and evaluation requirements, and lands not suitable for timber production. These six management decisions, but most especially forest plan goals and objectives, must be built upon a scientifically-based understanding of land and resource capability and suitability. These suitability and capability characteristics are depicted in ways that can be aggregated to various scales for analyses of scope and effect and disaggregated to meaningful scales for making the management decisions at the forest or management area level.

An "ecological approach to management" both starts with and culminates in the six decisions made in forest plans. These decisions then drive the activities taken to implement the plans, including monitoring, and evaluation to determine if there is a need to update the six decisions.

Desired future conditions. Desired future conditions (DFC's) provide a portrayal of the land or resource conditions which are expected to result if goals and objectives are met (Draft Planning Regulations, 1992). Ecological units will be useful in establishing goals and methods to meet DFC's and, when combined with information on existing conditions, projecting responses to various treatments.

Ecological units can be related to past, present, and future conditions. Past conditions serve as a model of functioning ecosystems, and provide insight into natural processes. It's unreasonable, for example, to attempt to restore systems like oak savannas or old growth forests in areas where they did not occur naturally. Moreover, natural processes like disturbance or hydrologic regimes are often beyond human control. Ecological units will be helpful in understanding these processes and in devising DFC's that can be attained and perpetuated.

Desired future conditions can be portrayed at several spatial scales. Conflicting resource uses (e.g., remote recreational experiences versus developed motorized recreation, habitat management for area sensitive species versus edge species) can be minimized by considering the effects of projects at several scales of analysis. Ecological units will be useful in delineating land units at relevant analysis scales for planning DFC's (Brenner and Jordan 1991).

Resource management. The ecological unit hierarchy will be useful in managing resources and in setting management objectives. Managers may want to consider the influence of climatic stressors or the potential successional pathways associated with ecological units while making management prescriptions (Host et al. 1987). Information on ecological units will support management activities such as the protection or restoration of habitats of sensitive, threatened, and endangered species and the improvement of forests and rangelands to meet human

needs. Information on existing vegetation growth rates can be compared to potentials determined for landtype phases to identifying areas producing less than their potential (Host et al. 1988). In cases, managers may want to emulate natural processes that can be related to the nature and distribution of ecological units.

Monitoring. Monitoring the effects of management requires baseline information on the condition of ecosystems at different spatial scales. Effects induced by management may be departures from these baselines. Landscape, community and species level biological diversity, forest productivity, air and water quality, and other concerns can be approached by establishing baselines for ecological units, and monitoring changes.

Evaluation of air quality is a specific example of how the ecological unit hierarchy can be used for baseline data collection and monitoring. The Forest Service is developing a National Visibility Monitoring Strategy that addresses protection of air quality standards mandated by the Clean Air Act, along with other concerns (USDA Forest Service 1993). Key to this plan is stratification of the United States, at the subregion level of the national hierarchy, into areas that have similar climatic, physiographic, cultural, and vegetational characteristics. Other questions dealing with effects of specific air-borne pollutants on forest health, such as correlation of ozone with decline of Fraser fir (*Abies fraseri*) ecosystems on high peaks in the southern Appalachians, will require establishment of sampling networks in smaller ecological units, at the landscape level.

Through the ecological unit hierarchy, the manager has information about the geographic patterns in ecosystems. They are, thus, in a position to design efficient sampling networks for inventory and monitoring. Ecological units recur in predictable patterns within a region: representative sites may be sampled, with information about ecosystem behavior extrapolated to analogous (unsampled) sites, thereby reducing cost and time in inventorying and monitoring (Bailey. 1991).

Emerging issues. The hierarchical framework for ecological units is based on associations of ecological factors. These associations will be useful in addressing emerging issues.

Concerns regarding biological diversity can be addressed using the ecological unit hierarchy (Probst and Crow 1991). Species are often rare, threatened or endangered because their habitat is being lost or degraded, because they are endemic to a particular area, or because they are at the edge of their natural range. In the first two instances, protection or recovery efforts are warranted. In the latter case, however, it may be futile and "un-natural" to try to maintain biota in environments where they are pre-disposed to decline. At a minimum, populations at the edge of their range can be evaluated for genetic diversity, and recovery programs administered accordingly. Species and community distributions can often be related to ecological units. In these cases, ecological units will be useful in their inventory and protection.

The new emphasis on sustaining and restoring the integrity of ecosystems may aid in arresting the decline of biological diversity, and preempt the need for many future protection and recovery efforts. Developing basic information on

the nature and distribution of ecosystems will enable us to better respond to emerging issues like global warming, forest health, and biological diversity.

Conclusion

The hierarchical ecological unit framework is under development to improve national, regional, and forest planning efforts. It is our intent to use the best available scientific knowledge available and to work with our partners and other agencies in its development. One objective is to improve our ability to share information between forests, stations, and regions to help facilitate inter-regional assessments of ecosystem conditions. A variety of work activities need to be initiated by the regions and stations if we are to utilize ecological units in our implementation of ecosystem management principles. Specifically, the regions and stations under the National Forest System need to coordinate their design of ecological units at higher levels of the national hierarchy. Development of landscape and land unit maps within the regions under the National Forest System should be coordinated by appropriate regional, station, and forest level staff (e.g., soil scientists, hydrologists, geologists, foresters, range conservationists, fisheries and wildlife biologists, and plant ecologists). As appropriate, new technologies (e.g., remote sensing, GIS, expert systems) should be utilized in both the design and testing of ecological unit maps.

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